ESSENTIALS OF CHEMISTRY.

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ESSENTIALS

OF

CHEMISTRY

INORGANIC AND ORGANIC

FOR THE USE OF STUDENTS IN MEDICINE

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PREFACE.

THIS little volume is designed to fill a vacancy hitherto left unoccupied by chemical writers; many valuable text-books have appeared within the past few years, none of these, as far as I am aware, are designed for or adapted to the special needs of the American medical student, and all are more or less overburdened with descriptions of technical and pharmaceutical processes which are of no direct importance to the practitioner in medicine. In the following pages I have omitted all topics which are not "essential" to an understanding of those chemical problems which have a direct bearing upon the practice of medicine; more attention has been directed to the chemistry of therapeutics than to that of pharmacy, while physiological chemistry, which must now be regarded as one

of the most important foundations of rational medicine, has been treated of as fully as the limits of the volume will permit.

The modern system of notation has been adopted, and the principles of the atomic theory have been dealt with in such a manner as, it is hoped, will afford the student a firm groundwork for future study.

It has not been my intention to write a manual of analytical chemistry, as those already at the command of the student leave nothing to be desired; I have, therefore, given only such analytical processes as the physician may reasonably expect to make use of in the course of his daily practice.

Weights and measures are given in the metric system, and temperatures in degrees of the Centigrade scale.

R. A. W

New York, Oct., 1878.

ESSENTIALS OF CHEMISTRY.

INTRODUCTION.

1. *How do physical and chemical phenomena differ from each other?*

In the former the composition of the matter acted on remains unchanged, while in the latter it is altered; thus, when a cylinder of lime is strongly heated it becomes white hot and emits light; it is still lime, however, after the action of the heat, as it was before. This is a physical phenomenon. If now we throw this lime into hydrochloric acid it disappears, and, after the action has been completed, we find neither lime nor hydrochloric acid, but two new substances, one a solid, called calcic chloride, the other a liquid—water; both of which differ in their composition from the original substances, which have disappeared. This is a chemical phenomenon.

2. *What is chemistry?*

It is the science of chemical phenomena and of the laws governing them.

3. *How may we classify all matter?*

Into elements and compounds.

4. *What is an element?*

A kind of substance which we cannot, by any known means, split up into any two or more other kinds of substance; as iron, charcoal, oxygen. Elements are also called elementary or simple substances.

5. *What is a compound?*

A substance made up of two or more elements in definite proportions: as water, sulphuric acid, potash.

6. *How many elements are now known?*

Sixty-four.

7. *What is an atom?*

The smallest quantity of an elementary substance that can enter into chemical action.

8. *What is a molecule?*

The smallest quantity of any substance that can exist in a free state. Molecules nearly always contain two or more atoms; in molecules of elementary bodies these atoms are of the same kind, while in compound substances they are of different kinds, thus: The molecule of hydrogen is made up of two atoms of hydrogen, while the molecule of hydrochloric acid is made up of one atom of hydrogen united with one atom of chlorine.

9. *What are chemical symbols?*

Signs by which the elementary substances are expressed in chemical writing. The symbol of an element is generally the first (capital) letter of its Latin name, usually followed by one of the small letters, thus the symbol of hydrogen is H, that of chlorine Cl, and that of carbon C.

10. *Does the symbol express a definite or an indefinite quantity of the element?*

A very definite quantity, namely, one atom.

11. *What is a formula?*

A collection of symbols representing a molecule and expressing the number and kinds of atoms of which it is constituted; thus HCl is the formula of hydrochloric acid, and expresses that its molecule is composed of one atom of hydrogen and one atom of chlorine; H_2O is the formula of water, and shows that its molecule is composed of two atoms of hydrogen and one atom of oxygen.

12. *What is a chemical equation?*

An expression by means of symbols, numbers, and signs of a chemical action. The sign + is used as the equivalent of the word "and," and the sign = indicates that the substances whose formulæ are placed before it have acted upon each other (have "reacted") to produce the substances whose formulæ follow the sign, thus, the equation,

$$CaO + 2HCl = CaCl_2 + H_2O$$

indicates that one molecule composed of one atom of calcium and one atom of oxygen, and two molecules, each composed of one atom of hydrogen and one atom of chlorine, have acted upon each other; this action has produced one molecule composed of one atom of calcium and two atoms of chlorine, and one molecule composed of two atoms of hydrogen and one atom of oxygen. As matter cannot be lost, the same number of each kind of atom must occur before and after the = sign.

13. *What is the atomic weight of an element?*

The weight of one of its atoms as compared to the weight of an atom of hydrogen; thus, an atom

of hydrogen weighing 1, an atom of oxygen weighs 16, an atom of sulphur 32, and an atom of chlorine 35.5. This weight is relative and not absolute; what the absolute weight of an atom of hydrogen may be we do not know.

14. *What is molecular weight?*

The weight of the molecule of any substance, *i. e.*, the sum of the weights of the atoms comprising its molecule; thus, the molecules of hydrogen being composed of two atoms, H_2, its molecular weight is 2; hydrochloric acid being composed of one atom of hydrogen and one of chlorine, its molecular weight is $1+35.5=36.5$.

15. *State Dalton's first law.*

The relative weights of elementary substances contained in a compound is definite and invariable, *e. g.*, water contains 2 parts by weight of hydrogen and 16 parts of oxygen, never more and never less.

16. *State Dalton's second law.*

When two elements unite with each other to form more than one compound, the resulting compounds contain simple multiple proportions of one element as compared to a constant quantity of the other, *e. g.*, nitrogen and oxygen unite with each other to form five compounds, in which for 28 parts by weight of nitrogen there is contained 16 parts by weight of oxygen, or some simple multiple of 16:

Nitrogen	monoxide	contains	28	parts	nitrogen	and 16	oxygen.
"	dioxide	"	28	"	"	$16\times2=32$	"
"	trioxide	"	28	"	"	$16\times3=48$	"
"	tetroxide	"	28	"	"	$16\times4=64$	"
"	pentoxide	"	28	"	"	$16\times5=80$	"

17. *State the law of equivalent proportions.*

An element, in combining with other elements,

or in replacing them in their compounds, does so in a fixed proportion, which may be represented numerically; *e. g.*, if we immerse in a solution of nitrate of silver a strip of copper, nitrate of copper and metallic silver will be formed; for every 108 parts of silver separated 31.7 parts of copper are dissolved, and we find that in all other reactions 108 parts of silver exactly equalize 31.7 parts of copper; these quantities are said to be equivalent.

18. *What is the "valence" of an element?*

The combining power of one of its atoms as compared with that of hydrogen. Atoms of certain elements, such as chlorine, are found to be equal in combining power to those of hydrogen, *i. e.*, one atom of chlorine is equal to one atom of hydrogen, such elements are said to be *univalent;* atoms of other elements, as oxygen, are found to be equal in combining power to two atoms of hydrogen, these are said to be *divalent;* so other elements are said to be *trivalent*, *quadrivalent*, *quinquivalent*, *sexivalent*, as their atoms are equal in combining power to three, four, five, or six atoms of hydrogen. The valence of an element is expressed symbolically thus: $'$ univalent, $''$ divalent, $'''$ trivalent, ^{iv} quadrivalent, ^{v} quinquivalent, and ^{vi} sexivalent, the sign being placed over and to the right of the symbol of the element, thus: O'', P^{v}.

OXYGEN. O″.16.

19. *What is the symbol of oxygen?* O.
20. *What its valence?* Divalent.
21. *What its atomic weight?* 16.

22. *How is it prepared?*

By decomposing a compound rich in oxygen. Potassium chlorate is generally decomposed by heat, when oxygen is given off and potassium chloride remains. The chlorate is heated in a retort of difficultly fusible glass, or preferably of metal, which should not be more than a third or half full; the gas is collected over water. By mixing with the chlorate an equal weight of manganese dioxide the liberation of oxygen takes place at a lower temperature. When this mixture is used care must be had that the manganese compound has not been adulterated, and that no organic matter is present, lest an explosion occur. The gas produced from this mixture must be washed by causing it to bubble through a solution of potash to separate a small quantity of chlorine which is formed. This precaution is essential if the gas is to be used for inhalation.

23. *State the more prominent physical properties of* O.

It is a colorless, odorless, tasteless gas; heavier than air (sp. gr. 1.108 air = 1). Sparingly soluble in water; more readily soluble in absolute alcohol.

24. *Does O unite readily with other elements?*

Very readily, and compounds of oxygen with all other elements except fluorine are known.

25. *What is a compound of O with another element called?*

An oxide.

26. *What is meant by oxidation and combustion?*

By oxidation we mean the act of union of oxygen with another element. This process, like all chemical union, is attended by the liberation of heat,

and when it takes place rapidly, of light; the rusting of a given weight of iron is a slow oxidation, while the burning of the same in oxygen is a rapid oxidation; only the latter produces light, while in both cases the same amount of heat is liberated. By combustion, in a general sense, is meant the rapid union of the oxygen of the air with some other substance, as coal or phosphorus. In a wider sense, however, combustion may be defined as any chemical union of two substances attended by liberation of heat and light.

27. *What are meant by combustibles and supporters of combustion?*

By a combustible we understand a substance having a great tendency to unite rapidly with oxygen, such as phosphorus and sulphur; such substances burn with greater brilliancy in pure oxygen than in air, which is oxygen in a diluted form. By supporters of combustion we mean gases with which substances of the last class enter into chemical action attended by light and heat.

28. *Is the distinction in the last section a scientific one?*

No. The process of combustion being a union of two substances, each of these takes an equal part in the reaction. The air or oxygen burns quite as much as the jet of house gas which we say burns; indeed we may light a jet of oxygen in an atmosphere of coal gas when it will burn precisely as would a jet of coal gas in an atmosphere of oxygen.

29. *When we burn a candle what takes place, and how does the weight of the products compare with that of the candle?*

The substance of the candle is made up principally of two elements, carbon and hydrogen; these, uniting with the oxygen of the air, form compounds called carbonic anhydride and water, the former is an invisible gas and the latter passes off as steam. If, by a suitable arrangement, we collect and weigh these products of the combustion we find that their united weight is greater than that of the candle, and this increase in weight is equal to the weight of the oxygen which has been abstracted from the air and united to the carbon and hydrogen.

30. *Of what importance is oxygen in respiration?*

It is the only substance capable of maintaining the process for any length of time. The process of respiration is essentially an oxidation; the blood in the lungs gives off carbonic anhydride, which we have seen results from the combustion of carbon, and water which results from the oxidation of hydrogen. At the same time it removes oxygen from the air, this oxygen is then carried to the various tissues, composed largely of carbon and hydrogen, an oxidation takes place here with the production of carbonic anhydride and water, while heat is liberated.

31. *What is ozone?*

Oxygen in a peculiar condition of condensation; the molecule of oxygen is made up of two atoms while that of ozone contains three.

32. *Under what conditions is ozone formed, and to what extent?*

By several chemical reactions as in the action of sulphuric acid upon pure barium dioxide. In the decomposition of water by the battery. By pass-

ing non-luminous electric discharges through air or oxygen. No means has yet been devised of obtaining pure ozone, it is always mixed with a large proportion of oxygen.

33. *What are the properties of ozonized oxygen?*

It has the peculiar odor observed when a friction electric machine is in action. It is a more active oxidizing agent than oxygen. It is converted into oxygen by heat. It is a powerful bleaching agent.

34. *In what proportion does ozone exist in air, and how may it be detected?*

In very small quantity, not more than $\frac{1}{4000000}$ by weight. A strip of neutral litmus paper, half of which has been moistened with solution of iodide of potassium, indicates the presence of traces of ozone when the iodized portion alone turns blue upon exposure to the air tested.

HYDROGEN. H′. 1.

35. *What are the symbol, valence, and atomic weight of hydrogen?*

Its symbol is H, it is univalent. The weight of one atom of hydrogen is the unit of atomic weights, the standard with which the atoms are compared. its atomic weight is therefore 1.

36. *How does H exist in nature?*

It is not found free (*i. e.*, uncombined), but occurs very abundantly united with other elements in almost all animal and vegetable substances and notably in water.

37. *How is it prepared?*

By the decomposition of water (which is a compound of hydrogen and oxygen). Either: 1. By

the action of a galvanic current. 2. By certain metals having a great tendency to unite with oxygen, as sodium. 3. By the action of hot zinc or iron. 4. By the action of these metals (zinc or iron) on cold dilute sulphuric or hydrochloric acid. The last is the method which is usually resorted to. When obtained by this process, H is almost always contaminated with small quantities of other gases due to the presence of impurities in the zinc and acid used. When perfectly pure H is required it is better to resort to the decomposition of water by the battery.

38. *State some of the principal physical properties of hydrogen.*

A gas, colorless, odorless, and tasteless. It is the lightest known substance, being about 14½ times lighter than air. One litre of hydrogen weighs at 0°C, and 760 mm. barometric pressure, Grm. 0.0896.

39. *Is hydrogen combustible?*

It burns in an atmosphere of air or of oxygen with a pale blue flame, producing little light, but great heat.

40. *Is it a supporter of combustion or respiration?*

No; a taper introduced into a vessel of H is extinguished, the hydrogen itself burning at the mouth of the vessel. An animal introduced into an atmosphere of pure hydrogen dies, not from any active agency of the gas, but from lack of oxygen.

41. *What is the result of the burning of hydrogen in air?*

The formation of a compound of hydrogen and oxygen known as water.

42. *Explain what takes place when certain oxides, as those of iron or copper, are heated in hydrogen.*

At elevated temperatures the oxygen has a greater tendency to unite with the hydrogen than to remain combined with the other element, consequently the oxide is decomposed, water is formed and passes off as steam, while the metal remains:

$$\underset{\text{Cupric oxide.}}{CuO} + \underset{\text{Hydrogen.}}{H_2} = \underset{\text{Water.}}{H_2O} + \underset{\text{Copper.}}{Cu}.$$

Such an action is called a *deoxidation* or a *reduction*, and any substance which, like hydrogen, has a tendency thus to remove oxygen from its compounds is said to be a *deoxidizing* or *reducing* agent.

COMPOUNDS OF HYDROGEN AND OXYGEN.

43. *How many compounds of hydrogen and oxygen are known, and what are they?*

Two:

Hydrogen monoxide, or water, H_2O
" dioxide, or oxygenated water, H_2O_2

Water, H_2O.

44. *What is meant by synthesis and analysis?*

By synthesis is meant the union of two or more simple substances to form a compound; and by analysis the division of a compound into its constituent elements.

45. *How can we prove by analysis that water has the composition H_2O?*

If we pass the current of a battery through acidulated water, the water is decomposed into its constituent gases, and, collecting these separately, we find one to be pure hydrogen, and the other

pure oxygen; for every one volume of oxygen collected we will obtain two volumes of hydrogen, and if we weigh these gases we will find that the hydrogen formed weighing 2, the oxygen will weigh 16, and as each atom of oxygen weighs 16, and each atom of hydrogen 1, the molecule of water is composed of one atom of oxygen combined with two atoms of hydrogen, and its formula is consequently H_2O.

46. *State the law of Avogadro, also known as the law of Ampère.*

Equal volumes of all gases, under like conditions of temperature and pressure, contain equal numbers of molecules.

47. *What practical application has this law?*

In Q. 45 it is not necessary to weigh the gases, because the volume of hydrogen produced is double the volume of oxygen, and therefore there are twice as many molecules of hydrogen as of oxygen; as the molecule of hydrogen and that of oxygen are each composed of two atoms, it follows that the decomposition of water has resulted in the production of two atoms of hydrogen for each atom of oxygen. Again, the determination of the molecular weight of a substance is of importance, and its molecular weight is the weight of its molecule as compared to that of a molecule of hydrogen; if the body can be obtained in a gaseous state, its molecular weight is found by simply determining its specific gravity as compared with hydrogen, this specific gravity being simply the weight of a given volume of the substance as compared to the weight of the same volume of hydrogen; as these volumes contain equal numbers of

molecules, the proportion found to exist between the entire masses holds good between the individual molecules, and it is this proportion which is the molecular weight desired.

48. *How can we prove synthetically that the composition of water is H_2O?*

1. If we make a mixture of 2 volumes of hydrogen with 1 volume of oxygen, and pass through it an electric discharge, chemical union will take place, the gases will disappear entirely, and in their place will remain a small quantity of water. 2. If we burn hydrogen in an atmosphere of oxygen, and collect the result, we will find it to be water. If in No. 1 we use more than 2 volumes of hydrogen, or more than 1 volume of oxygen, the excess will remain after the union; this is in obedience to Dalton's first law (Q. 15).

49. *What influence has temperature upon a mixture of oxygen and hydrogen?*

At the ordinary temperature a mixture of oxygen and hydrogen remains such indefinitely, no chemical union taking place; but if the temperature be raised, even at a single point in the mixture, as by applying a lighted match, or by the passage of an electric discharge, union takes place, and proceeds through the entire mass with great rapidity, causing a violent explosion. This influence of temperature upon chemical action is one of great importance, and not to be lost sight of, especially in animal chemistry, as certain actions take place at the temperature of the body which are arrested when the temperature is raised or lowered a few degrees.

50. *What precaution is to be observed in experimenting with hydrogen?*

Mixtures of hydrogen with oxygen or air, in certain proportions, explode on contact with flame with great violence; care is therefore to be had that, before collecting the gas, all the air has been driven out of the apparatus; moreover, hydrogen should only be preserved in glass vessels (having no cracks) over water, as it is a very diffusible substance, and, if kept overnight in rubber or metallic vessels, there is danger that air may pass in and form an explosive mixture. Neglect of these precautions has produced very serious accidents.

51. *Explain the calcium light.*

The union of oxygen and hydrogen is attended with the liberation of much heat. If we direct a current of oxygen through a jet of burning hydrogen, or if (with proper precautions) we burn a mixture of the gases in proper proportions, we obtain a small, non-luminous, but exceedingly hot flame; if we introduce into this flame a substance, such as lime, which is not chemically altered by heat, it becomes white hot and produces a bright light.

52. *Where does water exist in the animal economy?*

In all parts.

53. *What functions does water perform in the economy?*

In the liquid parts it holds the solids in solution (and it is of all liquids the best solvent we have); in the semi-solids it maintains the peculiar consistency of these parts. Many of the constituents of the body contain water as a part of their composi-

tion, and when this water is driven off, their condition becomes so altered as to render them entirely unfit for the performance of their functions.

54. *By what channels is water eliminated from the system, and how does the amount discharged compare with that ingested?*

It is discharged in the urine, perspiration, expired air, and fæces. The amount discharged is greater than that ingested, the excess being formed by the oxidation of the hydrogen contained in the organic matters of the body.

55. *What substances render a water unfit for drinking?*

1. An excess of solid matter, as in sea-water and the water of mineral springs. 2. An excess of organic matter. 3. Poisonous metals, as lead, copper. (For "hardness," see Q. 753.)

56. *What is meant by organic impurity?*

Low forms of vegetable life; decomposing animal or vegetable matter; contamination from admixture of sewage or of discharges from tanneries and from certain factories.

57. *Give a rough method of detecting organic impurity.*

Put a pint of the water into a *perfectly clean* quart bottle, cork and shake strongly, remove the cork and inhale the air of the bottle. If the water be much contaminated and if the observer's sense of smell be acute, an offensive odor will be observed.

NOTE.—This method is *quite* rough, and only very bad water will produce an odor; the only method of determining accurately to what extent a water is contaminated with organic matter is by the use of Wanklyn's process, which, unfortunately, is not adapted to the use of medical practitioners.

58. *What waters are most liable to organic contamination?*

That of stagnant pools. That of rivers having a sluggish stream or flowing through towns or manufacturing districts. That of wells.

NOTE.—Of course the water of stagnant pools is never used for drinking purposes, while it is only by criminal neglect on the part of the sanitary authorities that drinking-water is contaminated with the refuse of towns or factories. Well-water, however, especially that of shallow wells or those near which a drain-pipe passes, very frequently is the medium through which disease is communicated. Indeed the water of many wells situated near houses is simply diluted urine, holding fecal matter in suspension and solution; this condition of things is bad enough when the excreta are those of healthy individuals, but when a typhoid or cholera patient appears upon the scene, the result is invariably an epidemic. Medical practitioners cannot be too suspicious of the water supply under these conditions, and if not capable themselves of making an analysis, should condemn a suspected well absolutely until a proper examination of the water and of the drains has been made.

59. *What poisonous metal occurs most frequently, and how may it be detected?*

Lead. Take two tumblers full of the water, place them upon a sheet of white paper and through one pass a current of sulphuretted hydrogen (prepared as described in Q 197). If the water through which the gas has been passed becomes perceptibly darker than the other it is contaminated with a deleterious metal, probably lead.

60. *What influence has the purity of water upon its power of dissolving lead?*

Perfectly pure, *unaerated* water has no action upon lead, and a bright strip of the metal will retain its lustre in it indefinitely, but if the water contain air in solution the lead becomes oxidized and the oxide dissolves in the water; the solvent

power of the water being increased by the presence of chlorides or nitrates; if, on the other hand, the water hold in solution carbonates or carbonic anhydride (commonly called carbonic acid gas), its power of dissolving lead is very much diminished, if not destroyed, because these form upon the surface of the metal a coating of lead carbonate, which is a compound insoluble in water and which protects the lead from any further action of the water.

61. *What practical indications may be drawn from the last question?*

1. Rain-water should never be collected from roofs covered with lead, or in leaden tanks, because such water contains no carbonates and is liable to contain nitric acid and nitrates, its solvent power for lead is therefore comparatively great. 2. A well or vessel for containing water should never have a leaden cover, because the water, evaporating from the surface, condenses upon the lead in a very pure form, as far as solids are concerned, but highly aerated; it thus dissolves a portion of the oxidized metal and, falling, carries it into the mass below.

62. *How may water be purified?*

By distillation and filtration. (By the former method, which consists of converting the water into steam by the action of heat and condensing the steam, an almost absolutely pure water may be obtained, provided the vessels are of a material not acted on by water at the temperature attained and provided no soluble gas be present. Unless very pure spring water be at hand, distilled water should be used in most chemical operations and in toxico-

logical analysis the distillation should be repeated at least twice and only new glass vessels used. Distilled water, although very pure, is by no means the best for drinking purposes, as, owing to the absence of air and carbonic anhydride, and probably also of a small quantity of mineral matter, it is flat in taste and difficult of digestion.) Filtration is the method usually adopted for the purification of drinking-water, and consists in passing the water through a substance which retains any solid particles which may be held in suspension. If animal charcoal be used as the filtering medium, not only are particles in suspension arrested, but organic matter in solution is also, to a great extent, destroyed by oxidation.

63. *What is a hydrate?*

A substance derived from water by the substitution of an element or a radical* for one half of its hydrogen.

H_2O	HKO
Water.	Potassium hydrate.
$2H_2O$	CaH_2O_2
	Calcium hydrate

64. *What is the group (HO) called?*

Hydroxyl.

65. *What is water of crystallization, and what symbol is used to denote it?*

Many substances, upon assuming the crystalline form, take with them a definite number of molecules of water, which are necessary to the maintenance of the peculiar form, but which in no way modify the chemical properties of the substance.

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* See Q. 619.

This is called water of crystallization, and is denoted by the symbol Aq. (Latin aqua=water).

$SO_4Na_2,10Aq.$

Sodic sulphate with 10 molecules water of crystallization.

66. *Explain the terms* anhydrous, deliquescent, *and* efflorescent.

A substance is *anhydrous* when it contains no water. A *deliquescent* substance is a solid that has such a tendency to unite with water that it absorbs it from the air, becoming damp, and finally fluid. Crystalline bodies are *efflorescent* when on exposure to air they lose their water of crystallization and fall to powder.

NITROGEN. N''' 14.

67. *What are the symbol, valence, and atomic weight of nitrogen?*

Its symbol is N. It is trivalent or quinquivalent. Its atomic weight is 14.

68. *State the more prominent properties of nitrogen.*

It is a colorless, odorless, tasteless gas; lighter than air (sp. gr. 0.972 — air=1). Very sparingly soluble in water, more soluble in alcohol. Chemically, it is noticeable from its negative characters. It does not burn or support combustion. It does not unite with other elements directly, or does so with great difficulty. Its compounds are nearly all very prone to decomposition. It does not support respiration, but has no positive deleterious action upon the economy.

MIXTURE OF NITROGEN AND OXYGEN.

Atmospheric Air.

69. *What are the distinctions between a mixture and a chemical compound?*

In the former the proportions of the substances may vary indefinitely, while in the latter they are fixed and invariable. In a mixture the component parts retain their individual characters, while in a chemical compound these are lost and new characters appear, differing more or less widely from those of the original substances.

70. *What are the constituents of atmospheric air?*

Oxygen and nitrogen; with small quantities of carbonic anhydride, vapor of water, ammonia and nitric acid.

71. *What is the proportion by volume of nitrogen to oxygen in air?*

79 of nitrogen to 21 of oxygen.

72 *Does this proportion vary much in free air?*

No; although air is a mere mixture, the proportion of its chief constituents remains pretty much the same at different times, seasons, and elevations above the sea level.

73. *What is the function of the nitrogen in air?*

To dilute the oxygen.

74. *What is observed with regard to the solubility of air in water?*

All water, even that which has been recently distilled, contains air in solution, and it is from the air so held in solution that aquatic animals breathing by means of gills obtain the oxygen which they require. As air is a mixture, it has

not a solubility of its own, but each constituent gas is dissolved according to its solubility, and as oxygen is more soluble in water than nitrogen, the air in solution in water has not the composition 79 nitrogen to 21 oxygen, but 65 nitrogen to 35 oxygen.

(See carbonic anhydride, Q. 722 *et seq.*)

Compound of Nitrogen and Hydrogen.

75. *What are the name and formula of the compound of nitrogen and hydrogen?*

Ammonia—NH_3.

76. *What are its properties?*

It is, under ordinary conditions of temperature and pressure, a colorless gas having a pungent, irritating odor and a caustic taste. It is of all gases the most soluble in water, and is also very soluble in alcohol.

77. *Are gases more soluble in cold or in hot water?*

In cold water. In the case of ammonia 1 volume of water dissolves at 0°C. —1050 volumes; at 15° C. —727 volumes; at 20° C. —682 volumes, and at 100° the gas is all driven off.

78. *How do the specific gravity and volume of solutions of ammonia vary with the amount of gas dissolved?*

As the amount of gas dissolved increases, the specific gravity diminishes and the volume increases.

79. *What are the strengths and specific gravities of the aquæ ammoniæ of the U. S. Pharmacopœia?*

The aqua ammoniæ fortior, or stronger water of ammonia, contains 26 per cent. of gaseous ammo-

nia and has a sp. gr. of 0.9078 at 14° C., while the aqua ammoniæ contains 10 per cent. of the gas and has a sp. gr. of 0.959.

80. *Under what popular names is aqua ammoniæ known?*

Spirits of hartshorn; volatile alkali.

81. *What is the spiritus ammoniæ U. S. P.?*

A solution of ammonia in alcohol containing about 10 per cent. of the gas.

82. *What effect has great cold and pressure upon ammonia?*

When cooled to −40° at the ordinary pressure, or to −10° under a pressure of 6½ atmospheres, ammonia is reduced to a colorless, mobile liquid, which at −80° forms a solid crystalline mass.

83. *Are there any "permanent" gases?*

No. Certain gases maintained their gaseous form in spite of the greatest cold and pressure which could be brought to bear upon them, and were therefore called permanent gases. Recently it has been found, however, that by increased pressure and diminished temperature even these could be reduced to liquids or solids; there therefore remain no permanent gases.

84. *Under what conditions is ammonia combustible?*

Under ordinary conditions ammonia will not burn in air; if, however, we boil aqua ammoniæ in a wide-mouthed flask and pass through it a current of oxygen, the mixture of ammonia and oxygen may be ignited at the mouth of the flask; burning with a yellow flame. A mixture of 4 volumes NH_3 with 3 volumes O, explodes on contact with flame.

(For ammonium compounds, see Q. 426 *et seq.*)

Compounds of Nitrogen and Oxygen.

85. *What compounds of N and O are known?*

Nitrogen	monoxide	N_2O
"	dioxide	NO
"	trioxide	N_2O_3
"	tetroxide	NO_2
"	pentoxide	N_2O_5

86. *Explain the principle of this system of nomenclature.*

When two elements unite with each other to form a number of compounds, that number of atoms of the one varying least in quantity, which is combined with the smallest number of atoms of the other element, is taken as a standard of comparison. That compound in which this standard number of atoms is united with one atom of the other element is designated by the prefix *mono;* with two atoms by the prefix *di;* with three *tri;* with four, *tetra;* with five, *penta*, and with six *hexa.* Thus, in the case of these compounds, N_2 is taken as the standard; nitrogen monoxide contains for every two atoms of nitrogen one of oxygen; the dioxide for every two atoms of nitrogen two of oxygen, etc.

87. *By what other names is nitrogen monoxide known?*

Nitrous oxide; laughing gas.

88. *By what method is it prepared?*

By heating ammonium nitrate to a temperature not exceeding 250°, when it is split up into N_2O and water—thus:

$$\underset{\text{Ammonium nitrate.}}{NO_3(NH_4)} = \underset{\text{Nitrogen monoxide.}}{N_2O} + \underset{\text{Water.}}{2H_2O}$$

89. *State some of the physical properties of N_2O.*

It is a colorless, odorless gas, having a sweetish taste; heavier than air, sp. gr. 1.527; somewhat soluble in water, more so in alcohol.

90. *How does N_2O rank as a supporter of combustion and respiration?*

After oxygen, it is the best we have; a glowing match-stick rekindles when immersed in the gas, as it does in oxygen; phosphorus and other combustible substances burn in N_2O with almost as much brilliancy as in oxygen, this being due to the fact that at the temperature produced N_2O is decomposed into N and O, and in this mixture the O is in much larger proportion than in air. An animal will also live longer in an atmosphere of N_2O than in any other gas than air or oxygen; but, although the supply of gas be maintained, and the products of respiration be removed, the animal eventually dies of asphyxia.

91. *What effect has N_2O upon the system when inhaled?*

It produces, first, an exhilaration of spirits, frequently accompanied by laughter, and a tendency to muscular exertion, the patient sometimes becoming aggressive; afterwards, loss of consciousness and complete anæsthesia.

92. *What precautions are to be observed in the preparation and use of N_2O as an anæsthetic?*

First, that the gas be pure. The temperature of the retort must not be allowed to rise beyond the point indicated, lest the gas produced be contaminated with nitrogen dioxide and nitric acid; the ammonium nitrate used should be *pure*, and absolutely free from ammonium chloride, or the

N_2O will be contaminated with chlorine. In the administration, it must not be forgotten that N_2O alone is not capable of supporting respiration indefinitely; indeed, there is reason to believe that the anæsthesia produced is due to partial asphyxia.

93. *By what other name is nitrogen dioxide known?*

Nitric oxide.

94. *How is NO prepared?*

By the action of copper on nitric acid:

$$8NO_3H + 3Cu = 2NO + 3(NO_3)_2Cu + 4H_2O$$

Nitric acid. Copper. Nitrogen dioxide. Cupric nitrate. Water.

95. *What are its physical properties?*

A colorless gas, sparingly soluble in water. Its taste and odor are unknown.

96. *What takes place when NO comes in contact with air or oxygen?*

Under these conditions, NO immediately unites with O to form NO_2.

97. *What is another name for nitrogen trioxide?*

Nitrous anhydride; improperly, nitrous acid.

98. *What is meant by an anhydride?*

An oxide which will unite with water to form an acid—thus:

$$N_2O_3 + H_2O = 2NO_2H$$

Nitrogen trioxide. Water. Nitrous acid.

99. *Under what name is nitrogen tetroxide sometimes improperly designated?*

Hyponitric acid.

100. *State its properties.*

It is a brown gas, having a disagreeable, suffocating odor; it is very irritating to the respiratory

passages, colors the skin yellow, and is an energetic oxidizing agent. It is remarkable for assuming all three conditions of matter in a short range of temperature, being gaseous above 28°, liquid at about −12° and solid below −20°.

101. *How is it formed?*

Whenever a metal, as copper, silver, or mercury, is dissolved in nitric acid, the acid is decomposed, as in Q. 514; the NO formed, as soon as it comes in contact with air, absorbs O and is converted into NO_2. As this gas is very deleterious, care should be had that it have a free exit into the open air whenever nitric acid is decomposed, as in the formation of metallic nitrates.

102. *What is another name for nitrogen pentoxide?*

Nitric anhydride.

103. *How many nitrogen acids are there, and what are they?*

Two:

Nitrous acid—NO_2H.
Nitric acid—NO_3H.

104. *What is meant by an acid?*

An acid is a compound containing hydrogen in which, when acted on by a metallic hydrate, the hydrogen may be replaced by a metal while water is formed, thus:

NO_3H	+	KHO	=	NO_3K	+	H_2O
Nitric acid.		Potassic hydrate.		Potassic nitrate.		Water.

105. *What is a metallic hydrate?*

A compound of a metal united with hydrogen and oxygen. Such compounds are also called *bases.*

106. *What is a salt?*

An acid in which the hydrogen has been partially or entirely replaced by a metal or metals.

107. *What is understood by the reaction of a substance?*

All the acids and some salts have the power of reddening certain vegetable blue colors such as solution of litmus; these are said to have an acid reaction. Certain other substances, as the hydrates of sodium and potassium, have the power of restoring the blue color of litmus after it has been reddened by an acid; these substances are said to be alkaline in reaction. When a substance will neither redden litmus nor restore its blue color when reddened it is said to be neutral.

108. *What is a nitrite?*

A salt of nitrous acid. The acid itself does not exist, but quite a number of the salts corresponding to it are known.

109. *What is a salt of nitric acid called?*

A nitrate.

110. *What is the difference between two acids composed of the same elements, the name of one ending in* ous, *that of the other in* ic?

The *ous* acid contains less oxygen in proportion to the other elements than the *ic*, thus:

Nitrous acid	contains	less	oxygen	than	nitric acid.
Sulphurous acid	"	"	"	"	sulphuric acid.
Phosphorous	"	"	"	"	phosphoric "

111. *By what names are the salts of these acids distinguished from each other?*

When the name of the acid terminates in *ous* the name of the salt always terminates in *ite;* when

the name of the acid terminates in *ic* the names of its salts terminate in *ate*, thus :

A nitrite is a salt of nitrous acid—a nitrate a salt of nitric acid.
A sulphite " sulphurous " —a sulphate " sulphuric "
A phosphite " phosphorous " —a phosphate " phosphoric "

111a. *What is the formula of nitric acid?*

NO_3H.

112. *How does it exist in nature?*

It exists in combination with the metals as nitrates; those of potassium and sodium are the most abundant and are the chief sources of nitric acid. Ammonium nitrate occurs in small quantities in atmospheric air, especially after thunder showers.

113. *What is the principle of the manufacture of NO_3H?*

Sulphuric acid is caused to act upon potassium or sodium nitrate, when :

$$\underset{\text{Potassium nitrate.}}{NO_3K} + \underset{\text{Sulphuric acid.}}{SO_4H_2} = \underset{\text{Hydro-potassic sulphate.}}{SO_4HK} + \underset{\text{Nitric acid.}}{NO_3H}$$

114. *What are the physical properties of pure nitric acid?*

A colorless liquid, having a penetrating odor and an intensely sour taste. When cooled to — 50° it forms a solid, it boils at 86°.

115. *State some of the chemical properties of NO_3H.*

When exposed to the air it rapidly absorbs water and gives off white fumes. It has a strong acid reaction, turning blue litmus red and neutralizing alkalies. It acts energetically upon all animal tissues, decomposing them and turning such as

contain albuminoid substances yellow. It gives up part of its oxygen with great readiness and is therefore a powerful oxidizing agent. It is readily decomposed by most metals with formation of a nitrate.

116. *Name and describe the varieties of NO_3H met with in commerce and pharmacy.*

Chemically pure (C. P.) acid: Perfectly colorless; sp. gr. 1.521. Should be kept in bottles completely full, and protected from the action of light.

Commercial: A yellow liquid, contaminated with the lower oxides of nitrogen, hydrochloric acid, arsenic, and other impurities. Should never be used medicinally and only in rough chemical operations.

Fuming: A concentrated acid containing much nitrogen tetroxide, which gives it a deep yellow color. It is a powerful oxidizing agent.

Acidum nitricum, U. S. P.: A pure acid diluted with water, and containing 70 per cent. NO_3H. Used as an escharotic; sp. gr. 1.42.

Acidum nitricum dilutum, U. S. P.: The last diluted with water to sp. gr. 1.068, and containing 11.5 per cent. of pure acid.

117. *How may nitric acid be detected?*

Add to the liquid an equal volume of strong sulphuric acid, cooling during the mixture, pour it carefully upon the surface of a solution of ferrous sulphate; if NO_3H be present a black ring is formed at the junction of the two fluids. Drop a crystal of brucia into the fluid, if it contain NO_3H the alkaloid assumes a deep red color. All the nitrates are soluble in water.

118. *Define a poison.*

Any substance which, after absorption into the blood, produces death or serious bodily harm.

119. *Why are the mineral acids not poisons?*

Because they are deleterious from their local action upon important organs with which they are brought in contact, and independently of their absorption into the blood.

120. *How should these substances be classed, medically and legally?*

Medically, as corrosives or substances which corrode and destroy animal tissues as well after death as during life. Legally they are included under the terms "noxious or destructive things," always mentioned in statutes concerning poisoning.

121. *What is a common name for nitric acid?*

Aqua fortis.

122. *What should be the treatment when nitric acid has been swallowed?*

The object is to neutralize the acid, that is, to cause it to combine with a base and form a harmless nitrate; for this purpose the best agent is magnesia suspended in water. The stomach pump should never be used, nor should attempts be made to introduce the antidote through a tube, as there is great danger of pushing the tubes through the softened walls of the œsophagus or stomach.

ELEMENTS OF THE CHLORINE GROUP.

CHLORINE	Cl	35.5
BROMINE	Br	80
IODINE	I	127
FLUORINE	Fl	19

123. *What is the valence of elements of this class?*
They are all univalent.

CHLORINE.

124. *What are the symbol and atomic weight of chlorine?*
Its symbol is Cl, and its atomic weight 35.5.
125. *How does it exist in nature?*
It is not found free, but is very abundant in combination, notably in common salt.
126. *How is it prepared?*
There are three principal methods: 1. By the decomposition of its hydrogen compound (*i.e.*, muriatic acid) by black oxide of manganese:

$$MnO_2 + 4HCl = MnCl_2 + 2H_2O + Cl_2$$

Manganese dioxide. Hydrochloric acid. Manganous chloride. Water. Chlorine.

In this process 1 part of coarsely pulverized manganese dioxide is heated with 3 parts commercial muriatic acid. 2. By decomposition of common

salt, 1 part of which, mixed with 1 part of finely powdered manganese dioxide, is heated with 3 parts commercial sulphuric acid. 3. A convenient, but not economical, process consists in heating to the temperature of boiling water 2 parts of potassium dichromate with 11 parts of commercial muriatic acid. When comparatively small quantities of Cl are required, it may be obtained by exposing chloride of lime moistened with water or with dilute acid; this is a convenient method when the gas is required for disinfection of limited spaces or for inhalation.

127. *State the more prominent physical properties of Cl.*

It is a greenish-yellow gas, having a very penetrating, suffocating odor, acting energetically upon the air-passages even when dilute, producing coughing, inflammation, and hæmoptysis. It is 2½ times heavier than air, and, as it is quite soluble in water, should be collected by allowing the delivery tube to reach to the bottom of a jar, having its opening directed upwards, when the Cl collects from the bottom driving the air out above it (this is called collecting by displacement).

128. *What is aqua chlorinii, U. S. P.?*

A solution of Cl in water, saturated at the temperature of the air.

129. *Does Cl unite with other elements readily?*

It does. It unites directly with all elements except oxygen, nitrogen, and carbon, and with these it frequently unites indirectly; this union of Cl with other elements is frequently attended by the appearance of light and heat; when a candle is burnt in Cl, the hydrogen of the candle unites directly

with the Cl, giving off light and heat, while the carbon, being incapable of direct union with Cl, rises as a dense smoke.

130. *When chlorine and hydrogen combine what substance is formed?*

Hydrochloric acid.

131. *In what proportionate volumes do these two gases combine?*

In equal volumes.

132. *Under what conditions does the combination occur?*

A mixture of Cl and H may be kept indefinitely at ordinary temperatures and in the dark without union taking place. When the mixture is exposed to diffuse sunlight the combination takes place gradually, but if the mixture be exposed to the direct rays of the sun, or to certain strong artificial lights, or if a spark be passed through the mixture, combination occurs instantly with an explosion.

133. *What change takes place when a solution of Cl in H_2O is exposed to light?*

Under the influence of light Cl decomposes H_2O with formation of hydrochloric acid while oxygen is liberated:

$$\underset{\text{Water.}}{2H_2O} + \underset{\text{Chlorine.}}{2Cl_2} = \underset{\text{Hydrochloric acid.}}{4HCl} + \underset{\text{Oxygen.}}{O_2}$$

134. *Why is the equation in the last answer not written*

$$H_2O + 2Cl = 2HCl + O\ ?$$

Because that would indicate that a single atom of oxygen could exist uncombined; atoms when liberated from one combination immediately com-

bine with other atoms to form new molecules. (See Q. 8.)

135. *How does Cl act as a bleaching, deodorizing, and disinfecting agent?*

Indirectly as a powerful oxidizing agent; it decomposes the water present, according to the equation given above, and the oxygen, being in the nascent state, acts energetically. Cl will not bleach a perfectly dry substance.

136. *What is meant by the nascent state, and how is the superior energy of elements in this state explained?*

An element is said to be in the nascent state (the state of being born) at the instant that it is set free from one of its compounds. Free oxygen exists as a collection of molecules of oxygen, each molecule consisting of two atoms; when oxygen is liberated from a compound it is set free, first, as individual atoms, these, however, not being capable of existing free, immediately unite in pairs to form molecules, but if at the instant at which oxygen is liberated there be present any substance with which oxygen has a great tendency to combine, its atoms enter into combination with this rather than with each other. As the force required to break up the molecule of oxygen is in this case not required the combination takes place readily.

137. *What are the names and formula of the compound of chlorine and hydrogen?*

Hydrogen chloride or hydrochloric acid—HCl.

138. *What are the physical properties of this substance?*

It is a colorless gas; gives off thick white fumes on contact with moist air, has a very sharp pene-

trating odor, producing great irritation of the respiratory passages, and attacking the skin; reddens litmus; does not burn in air or support combustion; exceedingly soluble in water; heavier than air. (Sp. gr. 1.264.)

139. *What are the hydrochloric or muriatic acids of the arts and pharmacy?*

Solutions of this gas in water of varying strength and purity.

140. *What varieties are there? Describe them.*

Commercial: A yellow liquid having usually a sp. gr. of about 1.16; contaminated with iron and chlorides of sodium and arsenic; used for manufacturing and rough chemical purposes.

Pure: Acidum Muriaticum, U. S. P. A colorless liquid, being a pure solution of HCl in water, of about the same strength as the last. (Sp. gr. 1.16, U. S.)

Acidum muriaticum dilutum, U. S. P. The last named diluted with water to sp. gr. 1.038, and containing 10.5 per cent. of the gas.

141. *What is a chloride?*

A compound of chlorine with another element or radical.

142. *What does the termination* ide *indicate?*

That the compound is one containing two elements, or an element and a radical, thus:

An oxide	is a	compound	of	oxygen	with another element.
A chloride	"	"	chlorine	"	"
An iodide	"	"	iodine	"	"
A bromide	"	"	bromine	"	"
A sulphide	"	"	sulphur	"	"

etc.

143. *What is the action of hydrochloric acid with an oxide or a hydrate?*

Both are decomposed while water and a chloride are formed, thus:

$$\underset{\text{Calcium oxide.}}{CaO} + \underset{\text{Hydrochloric acid.}}{2HCl} = \underset{\text{Calcium chloride.}}{CaCl_2} + \underset{\text{Water.}}{H_2O}$$

$$\underset{\text{Sodium hydrate.}}{NaHO} + \underset{\text{Hydrochloric acid.}}{HCl} = \underset{\text{Sodium chloride.}}{NaCl} + \underset{\text{Water.}}{H_2O}$$

144. *How may a chloride be detected in a solution?*

By the formation of a white precipitate upon the addition of a solution of silver nitrate; the precipitate being insoluble in nitric acid but soluble in ammonium hydrate. (See Q. 426.)

145. *What chlorides are insoluble or very difficultly soluble in water?*

Those of lead, silver, and mercury (calomel).

146. *How may they be distinguished from each other?*

By adding ammonia, if the substance be silver chloride it is dissolved, if it be mercurous chloride it turns black, and if be lead chloride it remains unaltered.

147. *Does free hydrochloric acid exist in the body?*

Yes. It is the free acid of the gastric juice.

148. *What action has HCl upon the economy when taken internally?*

It acts as a corrosive, very like nitric acid but not so energetically.

149. *What treatment should be resorted to when HCl has been taken internally?*

The same as in the case of nitric acid.

150. *What is* aqua regia?

A mixture of nitric and hydrochloric acids in the proportion of $1NO_3H$ to $3HCl$ or three parts by

weight of nitric acid to 5 of hydrochloric; the acids react upon each other with liberation of Cl, which, being in the nascent state, combines with the noble metals gold and platinum if they be present, from which fact the name is derived; gold having been considered by the older chemists as the king of metals. The mixture is also known as nitrohydrochloric or nitromuriatic acid.

151. *What is a general characteristic of the compounds of chlorine with oxygen?*

They are all very unstable, being decomposed by very slight influences and frequently with explosion.

152. *What two acids of chlorine and oxygen exist in important salts?*

Hypochlorous acid, ClOH and
Chloric acid, ClO_3H.

(See sodium hypochlorite and potassium chlorate. Q. 419 and 389–391.)

153. *What compound of chlorine and nitrogen exists, and of what interest is it?*

Nitrogen chloride, probably having the composition NCl_3, is formed as an oily liquid whenever chloride of ammonium (sal ammoniac) is in presence of gaseous chlorine. It is one of the most violent explosives known, and care must be had that the conditions for its formation be not accidentally fulfilled.

BROMINE.

154. *What are the symbol, valence, and atomic weight of bromine?*

Its symbol is Br., it is univalent, and its atomic weight, 80.

155. *What are its physical properties?*

It is a dark brown liquid, giving off brown fumes freely when exposed to the air; has a strong, disagreeable odor, and is very irritating to mucous surfaces. It is sparingly soluble in water.

156. *How does bromine exist in nature?*

It is not found free, but exists in small proportion, widely diffused, however, in combination with potassium, sodium and magnesium, in sea-plants, and in the waters of the sea and of certain mineral springs.

157. *What is a compound of bromine with another element called?*

A bromide.

158. *How does bromine compare with chlorine in its chemical actions?*

Its actions are very similar to those of chlorine, but less intense; it forms compounds similar to those of chlorine, and is a good bleaching and disinfecting agent. Chlorine drives bromine out of its combinations; when a bromide is brought in contact with chlorine, a chloride is formed, while bromine is set free.

159. *How may bromine or a bromide be detected?*

Free bromine forms a yellow compound with starch paste; it produces a yellowish white precipitate with nitrate of silver, which has the same characters as the chloride of silver. It gives a yellow solution with chloroform. In the case of a bromide in solution add a few drops of chlorine water (solution of Cl in water) and some chloroform; shake, allow to separate into two layers; if

a bromide was present, the chloroform layer (the lower) will be colored yellow or reddish yellow. (Care must be taken that too much chlorine water be not added.)

IODINE.

160. *What are the symbol, valence, and atomic weight of iodine?*

Its symbol is I, it is univalent, and its atomic weight is 127.

161. *How does it exist in nature?*

It is not found free, but exists in combination in sea and mineral waters and in all plants and animals inhabiting the sea; in cod-liver oil in small quantity. It is more abundant than bromine.

162. *State the principal physical properties of iodine.*

At ordinary temperatures it is a solid, having somewhat the appearance of scales of iron; it volatilizes at all temperatures, condensing in crystals in the upper part of the containing vessel, if it be closed, and being lost, if open. It has a peculiar odor and an acrid taste. It melts at 107°, and boils at 180°, being converted into beautiful violet vapors. It stains the skin brown.

163. *What is the solubility of iodine in water?*

It is very sparingly soluble in water. If the solution be allowed to stand over an excess of iodine, it becomes darker, and more seems to be dissolved; this is due to the fact that, on standing, the water is partially decomposed, with formation of hydriodic acid (see Chlorine, Q. 133), in a solution of which iodine is more soluble than in pure water. The presence of certain salts, as

potassium iodide, ammonium chloride or nitrate, etc., in water increases very materially its power of dissolving iodine.

164. *What is the solubility of iodine in alcohol, ether, chloroform, or carbon bisulphide?*

It is very soluble in all of these fluids; in the two former the solution is dark brown, and in the two latter violet.

165. *What is Liquor iodinii compositus, U. S. P.?*

A concentrated solution of iodine in an aqueous solution of iodide of potassium.

166. *What is tincture of iodine?*

A solution of iodine in alcohol of the strength of an ounce to the pint.

167. *What is the effect of diluting tinct. iod. with water, and what practical application is drawn therefrom?*

Iodine is more soluble in strong than in dilute alcohol, consequently as the tincture is diluted, a point is reached when the dilute spirit is no longer capable of holding the iodine in solution, and it is precipitated in a very finely divided state. For this reason tincture of iodine should never be administered internally, as the finely divided iodine, separated by dilution of the tincture in the stomach, attaches to the coats of that organ and may produce serious irritation.

168. *What is an iodide?*

A compound of iodine with another element.

169. *What substances is commercial iodine liable to be contaminated with?*

Water, coal, graphite, black oxide of manganese, and iodide of cyanogen.

170. *Which is the most important of these, and how may it be separated?*

Iodide of cyanogen, as it is a very poisonous substance. To detect, and at the same time separate it, proceed as follows: Put at least an ounce of iodine into a porcelain dish, cover this with a large glass flask filled with cold water, and heat the dish upon a water-bath; if iodide of cyanogen be present white acicular crystals will be observed upon the bottom of the flask, and if the heating be continued for about 20 minutes it will all have collected upon the flask, and may be thus separated.

171. *How may free iodine or an iodide be detected?*

Free iodine forms a violet solution with chloroform; when added to starch paste it gives a purple color, these reactions are not observed when the iodine is in combination (an iodide); in this case proceed as with bromides (Q. 159).

173. *Is iodine poisonous?*

It is.

174. *What compound of hydrogen and iodine is known?*

Hydriodic acid or hydrogen iodide, HI.

175. *What are its properties?*

When pure, it is a colorless gas, very soluble in water. Its concentrated aqueous solution has a strong acid reaction and fumes when exposed to the air. It is quite unstable, being decomposed by Cl, Br, oxidizing agents, sulphuric acid, etc. When exposed to the air the oxygen unites with the hydrogen of the acid, forming water, while the iodine is set free and dissolved in the remaining acid until this becomes saturated with iodine,

when the remainder is precipitated in the solid form. It acts with regard to metals and hydrates like hydrochloric acid.

176. *What is an iodate?*

A salt of iodic acid, IO_3H.

FLUORINE.

177. *What are the symbol, valence, and atomic weight of fluorine?*

Fl. Univalent. 19.

178. *Has it been obtained in a free state?*

It has not.

179. *What compound of fluorine with hydrogen is known, and what are its uses and properties?*

Hydrofluoric acid or hydrogen fluoride, HFl. A colorless gas above 15°, below that a colorless mobile liquid. It is used either as gas or in solution for etching on glass, which it attacks with great energy.

180. *How is HFl obtained, and what precautions are to be observed?*

It is prepared by the action of sulphuric acid upon a natural compound of Fl, called fluor spar:

$$\underset{\text{Calcium fluoride.}}{CaFl_2} + \underset{\text{Sulphuric acid.}}{SO_4H_2} = \underset{\text{Calcium sulphate.}}{SO_4Ca} + \underset{\text{Hydrogen fluoride.}}{2HFl}$$

The operation must be performed in vessels of lead or of platinum.

Great care is to be had that the gas is not inhaled, and that the skin is not exposed to it, as, in a few instants it produces painful blisters, afterwards forming open wounds which are very painful and heal with great difficulty.

ELEMENTS OF THE OXYGEN GROUP

OXYGEN	O	16.
SULPHUR	S	32.
SELENIUM	Se	79.5
TELLURIUM	Te	128.

181. *What is a common characteristic of this group?*

All its members are divalent, and each forms a hydrogen compound in which one atom of the element is combined with two atoms of hydrogen.

SULPHUR.

182. *What are the symbol and atomic weight of sulphur?*

Its symbol is S, and its atomic weight 32.

183. *State the prominent physical properties of sulphur.*

At ordinary temperatures it is a yellow solid, having neither odor nor taste, and insoluble in water. At 111° it melts to a yellow liquid, which at 160° becomes brown and thick, and at higher temperatures again more fluid, until about 400°, when it is converted into a brownish yellow gas.

184. *What is the difference between roll sulphur flowers of sulphur, and precipitated sulphur?*

Roll sulphur is prepared by pouring melted sulphur into moulds which are cooled. *Flowers* of sulphur are obtained by mixing vapor of sulphur with cold air, when the sulphur assumes the solid form as a great number of small feathery crystals. *Precipitated* sulphur, or lac sulphuris U. S. P., is obtained by decomposing a compound of sulphur, that element being precipitated in a very fine state of subdivision.

185. *In what liquids is sulphur soluble?*

In bisulphide of carbon and bichloride of sulphur.

186. *What is a compound of sulphur with another element called?*

A sulphide.

187. *What occurs when sulphur is heated in contact with air?*

It burns with a blue flame at about 250°, uniting with the oxygen of the air to form sulphur dioxide—SO_2.

188. *Does sulphur unite directly with any other elements?*

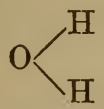
Yes; many metals burn in vapor of sulphur with formation of sulphides; sulphur also burns in an atmosphere of hydrogen with formation of hydrogen sulphide.

COMPOUNDS OF SULPHUR.

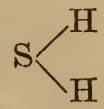
189. *What is an important compound of sulphur and hydrogen, and with what oxygen compound does it correspond?*

Hydrogen sulphide, also known as sulphuretted hydrogen—SH_2. It corresponds in constitution

with water, only in place of oxygen there is sulphur, and in each one atom of the divalent O or S is united with two atoms of univalent hydrogen.

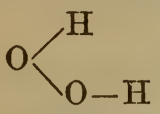


Water.
(Hydrogen oxide.)



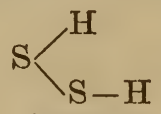
Hydrogen sulphide.

[There is another compound of sulphur and hydrogen corresponding to oxygenated water:



$=H_2O_2$

Hydrogen dioxide.



$=S_2H_2$

Hydrogen disulphide.]

190. *What are the principal physical properties of hydrogen sulphide?*

It is a colorless gas, having an exceedingly offensive odor of rotten eggs and a correspondingly disgusting taste. Heavier than air (sp. gr. 1.177). Under a pressure of 15 atmospheres it forms a colorless, mobile fluid which crystallizes at −85°. Soluble in water, the solution having an acid reaction and being decomposed with deposition of sulphur when exposed to the air for some time.

191. *What are the products of combustion of SH_2?*

If the supply of oxygen be small, with formation of water and deposition of solid sulphur,

$$\underset{\text{Hydrogen sulphide.}}{2SH_2} + \underset{\text{Oxygen.}}{O_2} = \underset{\text{Water.}}{2H_2O} + \underset{\text{Sulphur.}}{S_2}$$

if, however, the supply of oxygen be sufficient the products are entirely gaseous:

$$2SH_2 + 3O_2 = 2H_2O + 2SO_2$$

Hydrogen sulphide. Oxygen. Water. Sulphur dioxide.

Mixtures of air or oxygen with SH_2 are explosive.

192. *When SH_2 is passed through a solution of a metallic salt, what occurs?*

Both the gas and the salt are decomposed with formation of a sulphide and regeneration of the acid:

$$SO_4Cu + SH_2 = CuS + SO_4H_2$$

Cupric sulphate. Hydrogen sulphide. Copper sulphide. Sulphuric acid.

193. *What use is made of this reaction in analysis?*

The sulphides of the different metals, formed as above, vary in their color and in their solubility in acidulated water; therefore, by passing SH_2 through a solution, we can determine whether certain metals are present or not, according as insoluble colored precipitates are or are not formed. (See Appendix B.)

194. *Is SH_2 poisonous?*

It is.

195. *In what gaseous mixtures does SH_2 occur?*

In sewer gas, in the emanations from dead bodies, and in the gases discharged from volcanoes.

196. *What should be the treatment in SH_2 poisoning?*

Plenty of fresh air, cold affusions, hot brandy and water, inhalation of chlorine largely diluted with air.

197. *How may SH_2 be prepared?*

By treating ferrous sulphide with dilute sulphuric acid:

$$FeS + SO_4H_2 = SO_4Fe + SH_2$$

Ferrous sulphide. Sulphuric acid. Ferrous sulphate. Hydrogen sulphide.

198. *How may it be detected?*

By its action upon paper moistened with a solution of acetate of lead which it turns black by the formation of lead sulphide.

199. *How may it be destroyed when present in air?*

By mixing with it sulphur dioxide, q.v.

200. *What compound of sulphur and iodine is used in medicine, and how is it prepared?*

Sulphur iodide, S_2I_2; sulphuris iodidum, U.S.P., prepared by warming together flowers of sulphur and iodine, when direct union occurs.

OXIDES OF SULPHUR.

201. *What oxides of sulphur are known?*

Sulphur dioxide, SO_2
" trioxide, SO_3

202. *What is another name for sulphur dioxide?*

Sulphurous anhydride; also improperly called sulphurous acid.

203. *Why is the name* sulphurous acid *an improper one for this compound?*

Because it contains no hydrogen, which enters into the composition of every acid. The true sulphurous acid is a compound of the anhydride with water.

$$SO_2 + H_2O = SO_3H_2$$

Sulphurous anhydride. Water. Sulphurous acid.

204. *How may SO_2 be prepared?*

It is formed whenever sulphur is burnt in air,

but is more readily obtained by decomposing sulphuric acid with charcoal or metallic copper:

$$\underset{\text{Sulphuric acid.}}{2SO_4H_2} + \underset{\text{Carbon.}}{C} = \underset{\text{Sulphur dioxide.}}{2SO_2} + \underset{\text{Carbon dioxide.}}{CO_2} + \underset{\text{Water.}}{2H_2O}$$

$$\underset{\text{Sulphuric acid.}}{2SO_4H_2} + \underset{\text{Copper.}}{Cu} = \underset{\text{Cupric sulphate.}}{SO_4Cu} + \underset{\text{Water.}}{2H_2O} + \underset{\text{Sulphur dioxide.}}{SO_2}$$

The copper or coal with the requisite sulphuric acid are placed in a flask which is heated.

205. *State the physical properties of SO_2.*

At ordinary temperatures and pressure it is a colorless gas, having a suffocating odor (sulphur matches) and a disagreeable and persistent taste. More than twice as heavy as air (sp. gr. 2.217). Liquifies at $-10°$, and solidifies at $-60°$. It is very soluble in water, which takes up about 40 times its volume at the ordinary temperature.

206. *What is the acidum sulphurosum, U. S. P.?*

An almost saturated solution of SO_2 in water.

207. *Is this simply a solution of SO_2?*

No; it contains the true SO_3H_2, sulphurous acid formed by the union of $SO_2 + H_2O$.

208. *What is SO_2 used for?*

As a bleaching and disinfecting agent, and in the manufacture of sulphuric acid.

209. *Explain the bleaching and disinfecting action of SO_2.*

It is one of the strongest deoxidizing agents that we have, uniting readily with O which it removes from other substances. In the presence of water the true sulphurous acid is formed; this removes the oxygen from more water to form sulphuric acid while hydrogen is set free:

$$SO_3H_2 + H_2O = SO_4H_2 + H_2$$

Sulphurous acid. Water. Sulphuric acid. Hydrogen.

This hydrogen unites with the coloring or odorous principle to form compounds which are colorless or odorless. It also acts as a disinfectant in destroying hydrogen sulphide. (Q. 190.)

210. *What action has sulphur dioxide on the economy when inspired?*

In a concentrated form it is poisonous, when diluted with air it produces irritation of the air-passages. Individuals may, however, become by degrees habituated to its presence in air in quantities which would prove fatal to those not so trained.

211. *What substance is represented by the formula SO_3?*

Sulphur trioxide or sulphuric anhydride.

212. *State the properties of SO_3.*

It occurs as long, colorless, transparent prisms, which at 16° melt to an oily liquid, boiling at 46°. When exposed to the air it gives off dense white fumes. In the absence of water it has no effect upon litmus paper. It has a great tendency to unite with water to form sulphuric acid, and if dropped into water produces a hissing noise from the violence of the action.

SULPHUR ACIDS.

213. *What is the compound having the formula SO_3H_2?*

Sulphurous acid.

214. *What is a salt of sulphurous acid called?*

A sulphite.

215. *What is meant by saying that an acid is monobasic, dibasic, tribasic?*

An acid is *monobasic* when it has but one atom of hydrogen capable of being replaced by a metal; it is *dibasic* when it has two atoms of hydrogen capable of being so replaced; *tribasic* when it has three.

216. *Give an example of a monobasic acid.*

Hydrochloric acid.

217. *What is the basicity of sulphurous acid?*

It is dibasic.

218. *How many salts of an univalent metal and a monobasic acid can exist?*

Only one; one atom of the metal is capable of replacing one atom of hydrogen, and the acid only contains one atom of H capable of being so replaced; *e. g.*, the only possible salt of sodium and nitric acid is sodium nitrate, NO_3Na.

219. *How are the salts of the monobasic acids with divalent metals formed?*

An atom of the divalent metal displacing two atoms of hydrogen, and the monobasic acids only containing one atom of replaceable hydrogen in each molecule, the formation of salts by these two substances is only possible when two molecules of the acid combine and the atom of divalent metal replaces their united hydrogen, thus:

$$\underset{\text{Nitric acid (2 molecules).}}{2NO_3H} + \underset{\text{Zinc.}}{Zn} = \underset{\text{Zinc nitrate.}}{(NO_3)_2Zn} + \underset{\text{Hydrogen univalent.}}{H_2}$$

220. *How many salts may be formed by an univalent metal and a dibasic acid?*

Two. One in which only one of the atoms of hydrogen has been replaced by an atom of the

metal, *e. g.*, SO_4HNa; and another in which both atoms of hydrogen have been replaced by atoms of the metal, *e. g.*, SO_4Na_2.

221. *By what names are these salts distinguished from each other?*

The salt in which there remains some hydrogen is distinguished by the prefix *hydro*, thus:

SO_4H_2—Sulphuric acid or hydrogen sulphate.
SO_4HNa—Hydrosodic sulphate.
SO_4Na_2—Sodic sulphate or disodic sulphate.

Hydrosodic sulphate is also known as *acid* sodium sulphate, as it has an acid reaction with litmus, while the sodic sulphate, having no reaction with litmus, is known as *neutral* sodium sulphate. Hydrosodic sulphate is also known as bisulphate of soda; these last names however do not indicate the composition of the substance and are not used in scientific parlance.

222. *What is the formula of sulphuric acid?*

SO_4H_2.

223. *What is its basicity?*

It is dibasic.

224. *What is a salt of sulphuric acid called?*

A sulphate.

225. *Give a general idea of the principle of manufacture of sulphuric acid?*

Sulphurous anhydride is obtained by heating either sulphur or a natural compound of sulphur and iron, called iron pyrites, in a current of air. The anhydride thus obtained is caused to unite with water and oxygen.

$$\underset{\text{Sulphur. dioxide.}}{SO_2} + \underset{\text{Water.}}{H_2O} + \underset{\text{Oxygen.}}{O} = \underset{\text{Sulphuric acid.}}{SO_4H_2}$$

226. *What is another name for sulphuric acid?*

Oil of vitriol. The name is derived from the fact that SO_4H_2 is obtained by the distillation of sulphate of iron or vitriol.

227. *What are the properties of pure sulphuric acid?*

It is a dense, oily, colorless liquid; sp. gr. 1.842. It is intensely caustic, destroying organic matter with great energy, and must therefore be handled with great care. It boils at 338°, a part being decomposed, but the greater part distilling unchanged. It has a great tendency to unite with water, which it absorbs from the air, increasing thereby in volume; for this reason it should never be left exposed, lest it deteriorate in strength, and also, increasing in volume, overflow the vessel. Owing to this tendency of SO_4H_2 to unite with water, it chars and destroys organic matter. When diluted with water, great heat is produced; and to guard against accidents, the mixture should always be made in a vessel of thin glass, and the acid should be added to the water—never the water to the acid.

228. *Name and describe the varieties of this acid used in the arts and in pharmacy.*

Commercial: An oily fluid, with a brownish tinge (due to charred organic matter); sp. gr. 1.72, and containing 81 per cent. of true SO_4H_2.

Pure: Acidum sulphuricum, U.S.P., a colorless, oily fluid, having sp. gr. 1.842.

NOTE.—Practically, it is a matter of great difficulty to obtain *perfectly* pure SO_4H_2.

Acidum sulphuricum dilutum, U.S.P. The last acid diluted with water to sp. gr. 1.082, contains about 12 per cent. pure SO_4H_2.

Nordhausen oil of vitriol is a brown product, obtained by distilling sulphate of iron; manufactured principally for use in indigo-dyeing. It is very concentrated, and gives off thick, white fumes on exposure to moist air. It is a mixture of sulphuric acid with sulphuric anhydride.

229. *How may sulphuric acid or a soluble sulphate be detected?*

By adding to the suspected liquid a solution of barium chloride, having previously acidulated the solution with pure HCl, if it was not already acid. If SO_4H_2 be present, barium sulphate will be formed as an insoluble white precipitate.

230. *What treatment should be followed when sulphuric acid has been taken internally?*

The object in treatment is to neutralize the acid. Magnesia, chalk, and soap are indicated. See Q. 122.

231. *How may stains of sulphuric, hydrochloric and nitric acids on cloth be distinguished from each other?*

When not too old, stains of sulphuric and hydrochloric acids are bright red, the latter the brighter of the two. They disappear permanently when moistened with aqua ammoniæ. Those of nitric acid are of a yellowish tinge, and are not removed by aqua ammoniæ.

232. *What other sulphur acid forms some important salts?*

Hyposulphurous acid $S_2O_3H_2$, whose salts are called hyposulphites.

ELEMENTS OF THE PHOSPHORUS GROUP.

Nitrogen	N	14
Phosphorus	P	31
Vanadium	V	51.3
Arsenic	As	75
Antimony	Sb	122
Bismuth	Bi	210

233. *What peculiarity is observed with regard to the valence of elements of this group?*

They form two series of compounds, in one of which the atom is trivalent, and in the other it is quinquivalent.

PHOSPHORUS.

234. *What are the symbol and atomic weight of phosphorus?*

Its symbol is P, and its atomic weight, 31.

235. *Of how many atoms does the molecule of phosphorus consist?*

Of four.

236. *What is meant by allotropy?*

Some elements, as phosphorus and carbon, are found to exist in two or more different conditions, in which, although the chemical relations remain

unaltered, the physical properties vary more or less widely; these different conditions of the same element are said to be allotropic.

237. *In how many allotropic conditions does phosphor exist, and what are they?*

In two—the white or ordinary form, and the red or amorphous variety.

238. *What are the physical properties of the ordinary variety?*

When freshly prepared, and at ordinary temperatures, it forms a white or yellowish, translucent solid, which, on exposure to light, becomes more darkly colored and opaque; it has the consistency of wax, and is easily cut; when exposed to the air, it gives off white fumes and an odor of garlic. At 0° it becomes brittle, at 44° it melts to a yellowish fluid, and at 290°, in the absence of air, is converted into a colorless vapor. In air, at 60°, it ignites, burning with a bright flame, and giving off dense, white fumes. Owing to the readiness with which P. ignites, and the painful nature of the burns produced by it, it should never be cut, except under water, and should not be handled, except with forceps. In the dark this form of P. gives off a peculiar pale light. It is insoluble in water; sparingly soluble in alcohol, ether, and the fatty and ethereal oils; very soluble in bisulphide of carbon, from which solution it separates in the form of crystals.

239. *What are the physical properties of the red variety?*

It is red, brown, or dark yellow in color. It may be heated to 250° without melting, but at that temperature it is suddenly converted into the

white variety, which ignites with an explosion. It fires much less readily than white phosphorus, and may be kept dry, while the white must be preserved under water. It has no odor or taste, and is insoluble in those substances which dissolve the other form.

240. *What is the most important difference between the two forms?*

The white variety is exceedingly poisonous, while the red is entirely innocuous.

241. *How may white phosphorus be pulverized?*

By melting it under water, and agitating the mixture until it has cooled so far that the phosphorus has solidified in a finely divided form.

242. *How does phosphorus exist in nature?*

It is not found in its own form, but is widely distributed in combination in the three kingdoms of nature. In the animal it occurs both oxidized in the form of phosphates (the phosphorus used in the arts is obtained exclusively from calcic phosphate existing in bones) as well as in certain organic compounds entering into the composition of nerve tissue.

243. *How many varieties of phosphorus poisoning may occur, and what are they?*

Two. 1st. The acute form consequent upon the ingestion of a poisonous dose of the element; and 2d. The chronic form (also known as the Lucifer disease), affecting those engaged in certain branches of match manufacture.

244. *How does the acute form occur?*

The recorded cases are about equally divided between accidental, suicidal and murderous. The substances used being either match heads (which

are composed, in the common sulphur match, of potassium chlorate, fine sand, phosphorus, and a coloring matter), or rat poison, which is a mixture of phosphorus with flour.

245. *What circumstances affect the rapidity with which symptoms appear in these cases?*

The action is much accelerated by the presence of any oily or fatty matter, which dissolves the poison, and thus favors its absorption. The symptoms usually make their appearance within two to four hours after ingestion of the poison, but they may be delayed for days.

246. *What important peculiarity is observed in the urine and vomit in phosphorus poisoning?*

When shaken in the dark they shine with the pale light characteristic of the presence of unoxidized phosphorus.

247. *What treatment is to be followed?*

We have no chemical antidote; therefore, all efforts are to be directed to getting the poison out of the system as rapidly as possible. For this purpose the stomach-pump or an emetic of zinc sulphate are indicated. If the poison have had time to reach the intestine, a cathartic should also be administered. *Give no oily or fatty matter, or any substance containing them.* Oil of turpentine has been used with advantage as a physiological antidote. The older the oil the better its action seems to be.

248. *Describe Mitscherlich's process for detecting the poison.*

This process is based upon the property of unoxidized phosphorus of becoming luminous in the dark. The matters supposed to contain the poison

are rendered fluid by dilution with water and acidulated with sulphuric acid. They are placed in a flask upon a sand bath, and the flask connected with a Liebig's condenser, which is placed in absolute darkness. Upon heating the flask any phosphorus present is volatilized, and condensing in the tube forms a luminous ring. This reaction is very delicate, and the appearance of the ring is proof positive of the presence of unoxidized phosphorus.

249. *Under what conditions will this process fail?*

The presence of certain volatile substances destroys the luminosity of phosphorus; prominent among these are alcohol, ether, and oil of turpentine. In the case of the two former, which are quite volatile, the luminous ring does not appear until they have distilled over, and are thus separated. When oil of turpentine is present the luminous property of phosphorus is permanently destroyed; consequently, when it is known that this substance has been administered, this process should not be resorted to, and in any case only half the material should be used.

250. *Give a short description of the process of match manufacture.*

The wooden splints are dipped for about a third of their length in some combustible substance, as melted sulphur or paraffin; after this has set they are pointed with the phosphorus paste. This paste is spread out on an iron plate, which is warmed. During the process (when the mixture does not fire, which frequently occurs) fumes of the lower oxides of phosphorus are given off. After the pointing process the matches are arranged in the

drying-room, from which they are taken to be packed.

251. *What classes of operatives are liable to the lucifer disease?*

Those who are engaged in the manufacture of phosphorus are not attacked by it, but those who are engaged in the pointing, drying, and packing of matches. Weak and scrofulous females are more subject than others.

252. *How may this form of poisoning be diminished in frequency, and prevented?*

Many methods have been resorted to for this purpose. 1st. Strict cleanliness and good ventilation of the shop are imperative. 2d. The mouth is frequently washed with a weak solution of sodic carbonate. 3d. Saucers filled with turpentine are placed in the rooms. There is only one method, however, of completely remedying the evil, which is the absolute prohibition of the use of white phosphorus in the manufacture of matches. The increased cost of red phosphorus is more than counterbalanced by the advantages of preventing this fearful disease, and at the same time removing from the reach of the poisoner one of the most potent and easily obtained of toxic agents.

COMPOUNDS OF PHOSPHORUS.

253. *What is the composition of gaseous phosphoretted hydrogen?*

PH_3

254. *How may it be prepared?*

By the action of concentrated solution of caustic potash upon phosphorus, or by the decomposition of a compound of phosphorus and calcium by water.

255. *What are the properties of the gas as thus obtained?*

It is colorless and has a disgusting odor of rotten fish; almost insoluble in water, easily soluble in alcohol or ether. As each bubble of the gas comes in contact with the air it inflames and produces a ring of smoke. It is highly poisonous.

256. *What other substance is present in the gas as thus obtained, and what property is due to its presence?*

It is contaminated with small quantities of another compound of phosphorus and hydrogen, which is liquid at ordinary temperatures and has the composition P_4H_2; it is to the presence of this substance that it owes the property of igniting on contact of air. The pure gas only ignites when heated to 100°.

257. *How many compounds of phosphorus and chlorine are known, and what are they?*

Two. Phosphorus trichloride, $P'''Cl_3$,
Phosphorus pentachloride, P^vCl_5.

PCl_3 is a colorless liquid formed by the direct union of chlorine and phosphorus; when the chlorine is in excess the solid PCl_5 is formed.

258. *What compounds of phosphorus and oxygen are known?*

Two. Phosphorus trioxide, P_2O_3,
Phosphorus pentoxide, P_2O_5.

259. *Under what other name is P_2O_3 known, how is it formed, and what are its properties?*

Phosphorous anhydride. It is formed when phosphorus is slowly oxidized in a limited quantity of perfectly dry air or oxygen. As soon as it is exposed to air containing a small quantity of mois-

ture it ignites from the heat produced by its union with H_2O to form phosphorous acid.

260. *What is another name for P_2O_5, and how is it formed?*

Phosphoric anhydride. It is formed whenever phosphorus is burned, *i.e.*, rapidly oxidized, in a current of dry air or oxygen.

261. *What are its properties?*

It is a snowy white, flocculent powder, having a tendency to unite with water, which it absorbs from other substances greedily (owing to this property it forms a valuable drying agent), forming a highly acid liquid.

Phosphorus Acids.

Hypophosphorous acid	$-PO_2H_3$.
Phosphorous "	$-PO_3H_3$.
Orthophosphoric "	$-PO_4H_3$
Pyrophosphoric "	$-P_2O_7H_4$.
Metaphosphoric "	$-PO_3H$.

262. *What is a salt of hypophosphorous acid called, and what is the general formula of these salts?*

An hypophosphite. These salts have the formulæ PO_2H_2M' or $(PO_2H_2)_2M''$ in which M′ represents an atom of an univalent metal and M″ an atom of a divalent metal. It will be noticed that although the molecules of this acid contain three atoms of hydrogen, only one of these is capable of being replaced by a metal.

263. *What are the formula and basicity of phosphorous acid?*

PO_3H_3. It is dibasic; although it contains three

atoms of hydrogen only two of these are replaceable by a metal.

264. *How may it be prepared and what are its properties?*

It is best prepared by the action of water on phosphorus trichloride:

$$PCl_3 + 3H_2O = 3HCl + PO_3H_3$$

or by the slow oxidation of phosphorus in damp air; in both cases it is obtained in solution as a colorless, sirupy, and very acid fluid; it is a very powerful deoxidizing agent from its tendency to form orthophosphoric acid.

$$\underset{\text{Phosphorous acid.}}{2PO_3H_3} + \underset{\text{Oxygen.}}{O_2} = \underset{\text{Phosphoric acid.}}{2PO_4H_3}$$

265. *How does orthophosphoric acid occur in nature?*

It is not found free, but is very widely disseminated in combination in the phosphates.

266. *By what other names is it known?*

Common phosphoric acid or tribasic phosphoric acid.

267. *How is it prepared?*

By the direct oxidation of phosphorus by means of nitric acid. The reaction, which is dangerous when white phosphorus is used, is started by the application of heat and, once started, continues without further heating.

268. *What is the acidum phosphoricum dilutum, U. S. P.?*

A solution of orthophosphoric acid prepared as above, and diluted with water to sp. gr. 1.056 and containing 7.4 per cent. of acid.

269. *What is the basicity of this acid; how many series of salts does it form?*

It is tribasic; there are consequently three series of salts.

270. *By what names are these series of salts distinguished?*

PO_4H_3 = Phosphoric acid or hydrogen phosphate.

PO_4H_2Na = Dihydro-sodic phosphate.
PO_4HNa_2 = Hydro-disodic phosphate.
PO_4Na_3 = Trisodic phosphate.

or with divalent metals:

$(PO_4H_2)_2Ca$ = Monocalcic phosphate.
$(PO_4H)_2Ca_2$ = Dicalcic phosphate.
$(PO_4)_2Ca_3$ = Tricalcic phosphate.

271. *By what test may orthophosphoric acid or an orthophosphate in solution be detected?*

1. Add some solution of ammonium chloride containing free ammonia, and then solution of sulphate of magnesium; if phosphoric acid be present a white crystalline precipitate is formed.

[The same reaction occurs if an arseniate be present.]

2. To the neutral solution add solution of nitrate of silver; if phosphoric acid be present a yellowish white precipitate is formed, which dissolves on addition of nitric acid or of ammonia [If the precipitate were formed by an arseniate it would not be yellowish but brown or brick red.]

3. To dilute nitric acid add the solution to be tested, and then solution of ammonium molybdate; if phosphoric acid be present a yellowish precipitate is formed.

272. *Wherein does the* acidum phosphoricum glaciale, U. S. P., *differ from the ordinary phosphoric acid?*

It is an entirely different substance; it is not orthophosphoric acid, PO_4H_3, but metaphosphoric acid, PO_3H, which is not tribasic but monobasic. A very important difference between the two substances is that while the ortho-acid and its salts are comparatively inert, metaphosphoric acid and its salts exert a poisonous action upon the economy, acting upon the motor ganglia of the heart to produce a diminution in blood pressure, and in comparatively small doses, death from cessation of the heart's action.

ARSENIC.

273. *What are the symbol and atomic weight of arsenic?*

As. 75.

274. *Of how many atoms is the molecule of arsenic composed?*

Of four.

275. *How does arsenic exist in nature?*

In small quantities in the elementary form; more abundantly in three sulphur compounds; realgar, orpiment, and mispickel, the last being a compound of sulphur, arsenic, and iron, and the chief ore of arsenic. It also exists in small quantities in many ores and in traces in the waters of certain mineral springs.

276. *What are the properties of arsenic?*

It is a steel gray solid, having a metallic lustre; when pure it is odorless and tasteless; easily pow-

dered ; sp. gr. 5.6 to 5.9 ; when heated to 180°, without access of air, it distills unchanged and without melting. It is a good conductor of electricity.

277. *What action have air and water upon As?*

At ordinary temperatures it remains unchanged in *dry* air ; at high temperatures it unites rapidly with oxygen, producing a strong bluish white light. When pure it is insoluble in water, but when exposed to that fluid or to damp air it becomes tarnished from the formation of a film of oxide upon its surface, and this oxide is dissolved to a certain extent by the water.

278. *For what purposes is arsenic used in the arts?*

It is mixed with lead in the manufacture of shot ; it enters into the composition of fly poison, and is used in certain fireworks.

279. *What compound of arsenic and hydrogen is known?*

Arseniuretted hydrogen or hydrogen arsenide, AsH_3.

280. *Under what conditions is this substance formed?*

When nascent hydrogen is in presence of an arsenical compound.

281. *What are its properties?*

It is a colorless gas, having a penetrating garlic odor. When heated to redness it is decomposed, arsenic being separated in the elementary form. When ignited it burns with a bluish flame, giving off white clouds of arsenic trioxide. It is one of the most poisonous substances known, a single bubble of the pure gas having caused death.

282. *Name the compounds of arsenic and oxygen.*

Arsenic trioxide, As_2O_3.
Arsenic pentoxide, As_2O_5.

283. *Under what other names is arsenic trioxide known?*

Arsenious anhydride; white arsenic; and, improperly as arsenious acid; acidum arseniosum, U. S. P.

284. *What are the physical properties of As_2O_3?*

It occurs in two allotropic conditions. When freshly prepared it forms small, transparent, shining, eight-sided crystals, which on exposure to air become opaque, forming the heavy white powder known as white arsenic. If this substance be kept near its point of volatilization it melts, and, on cooling, forms the second variety which is a transparent, glassy, structureless mass, having a faint yellowish tinge; this variety is gradually converted into the first, upon the surface, by exposure to air, but if the mass be broken its interior will be found still glassy. These two varieties are both odorless and have a faint taste, somewhat acrid and metallic at first, afterwards sweetish; they differ from each other in their solubility in water, etc.

285. *What is the solubility of arsenic trioxide?*

The glassy variety is much more abundantly and more rapidly soluble in water than the opaque, the latter is wetted slowly by water which dissolves it slowly; when As_2O_3 is thrown upon cold water a portion sinks to the bottom and a portion floats upon the surface; if this be allowed to stand, the water will dissolve about one part As_2O_3 in a 1000, or 1 litre of water will contain 1 grm. As_2O_3; if we

pour boiling water upon As_2O_3 it will dissolve about one part in 400, while if we boil water with As_2O_3 for an hour it will dissolve one part in 40. The presence of hydrochloric acid in water increases its power of dissolving As_2O_3. The presence of any organic matter in the water (soup, tea, coffee, etc.) diminishes the quantity of As_2O_3, which the water is capable of dissolving.

NOTE.—In medico-legal cases it must not be forgotten that a poisonous substance may be swallowed with a drink without being in solution; if the beverage be mucilaginous, or be stirred immediately before drinking, the amount held in suspension may greatly exceed that held in solution.

286. *What is Liq. arsenici hydrochloricus*, U. S. P.?

A solution of arsenic trioxide in water acidulated with hydrochloric acid, containing 8.75 grm. As_2O_3 to the litre.

287. *If As_2O_3 be heated in a tube, what occurs?*

It volatilizes unchanged, and is deposited in the cool parts of the tube in the form of small, brilliant, white, eight-sided crystals.

288. *If heated in presence of charcoal, what occurs?*

It gives up its oxygen readily; carbonic anhydride is formed, while arsenic is deposited in the elementary form.

289. *How does As_2O_3 behave with oxidizing agents?*

It takes up oxygen readily; in aqueous solution, exposed to the air, a portion is converted into As_2O_5; with nitric acid, the action is more rapid, As_2O_5 being formed, while brown fumes are given off.

290. *What action has hydrogen sulphide on As_2O_3 in acid solution?*

Both substances are decomposed, the tersulphide of arsenic, As_2S_3, being deposited as an insoluble yellow powder.

291. *For what purposes is As_2O_3 used in the arts?*

In the manufacture of green pigments; of opaque white glass; in calico printing; in the preservation of animal substances by the taxidermist and in dissecting; as a vermin poison, and as the starting-point in the manufacture of all arsenical compounds.

292. *What is the true arsenious acid?*

This substance has not been isolated, but is considered as existing in solutions of arsenious anhydride, and having the formula AsO_3H_3 (corresponding to that of phosphorous acid); there are, however, a number of important salts corresponding to this acid, known as arsenites, and having the general formula $AsO_3M'_3$.

293. *What is Fowler's solution?*

A solution of potassium arsenite in water, containing comp. tinct. lavender to give it taste and odor, that it may not be mistaken for water.

294. *What is Scheele's green?*

Arsenite of copper.

295. *What is Schweinfurt green?*

A mixture of arsenite and acetate of copper.

296. *What is another name for arsenic pentoxide, and what are its properties?*

Arsenic anhydride. It is a heavy, white solid, gradually but rather abundantly soluble in water.

297. *What is arsenic acid?*

The solution of As_2O_5 in water is not only a solution, but a combination:

$$\underset{\text{Arsenic pentoxide.}}{As_2O_5} + \underset{\text{Water.}}{3H_2O} = \underset{\text{Arsenic acid.}}{2AsO_4H_3}$$

with formation of arsenic acid, which is quite soluble in water, the solution having acid qualities, and being more actively poisonous than As_2O_3.

298. *What phosphorus acid does arsenic acid resemble in its chemical properties?*

Orthophosphoric acid; it is converted into metarsenic and pyroarsenic acids under the same conditions under which phosphoric acid yields meta- and pyrophosphoric acids. Its salts, called arseniates, resemble in constitution the corresponding compounds of phosphoric acid.

299. *How may solutions of arsenious and arsenic acids be distinguished from each other?*

By solution of nitrate of silver in presence of ammonia; with solution of arsenious acid silver arsenite is formed as a *yellow* precipitate, while with solution of arsenic acid silver arseniate is formed as a *chocolate-brown* precipitate.

300. *For what purpose is arsenic acid used in the arts?*

It is largely used in the manufacture of red aniline dyes. One of its salts, sodic arseniate, AsO_4Na_3, is used in calico printing, and a solution in water of the same salt forms Liq. sodæ arseniatis, Br. P.

301. *What is realgar, and how does it occur?*

Arsenic disulphide, As_2S_2; it is found in nature in translucent red crystals, and is also manufac-

tured commercially by melting together arsenic trioxide and sulphur; as thus prepared it forms dark red amorphous masses, tasteless and odorless. In powder it is orange yellow, insoluble in water, alcohol, or dilute hydrochloric acid.

302. *How do the natural and artificial realgars differ in their action when taken internally, and why?*

The native realgar is inert, while the artificial product is poisonous. The sulphide is in both cases non-poisonous, but the artificial realgar always contains arsenic trioxide.

303. *Under what other name was realgar formerly known?*

In some older works it is known as *sandarach*, which name has since been app ied to a resin used in making incense, and to a slight extent in medicine.

304. *What is the common name for arsenic trisulphide, and how does it occur?*

Orpiment. It is found in nature as brilliant, yellow, gold-like scales and crystals; it is also manufactured artificially by subliming together arsenic trioxide and sulphur; this product, like artificial realgar, always contains arsenic trioxide which renders it poisonous. Pure As_2S_3 may be obtained by passing sulphuretted hydrogen through an acid solution of arsenic trioxide, and washing the deposit.

305. *What relation has As_2S_3 to As_3O_3, chemically?*

As As_2O_3 is the anhydride of arsenious acid, so As_2S_3 is the anhydride of an acid of similar composition, in which the oxygen is replaced by sul-

phur, called sulpharsenious acid, AsS_3H_3, and corresponding to which are salts called sulpharsenites.

306. *How is As_2S_3 used in the arts?*

As a pigment under the name *King's yellow;* mixed with lime and water, to form a paste called *rusma*, used in dressing hides, and as a depilatory.

307. *What other compound of sulphur and arsenic is known?*

Arsenic pentasulphide, As_2S_5.

308. *What is Donovan's solution?*

A solution of mercuric iodide and arsenious iodide, AsI_3.

309. *Name some of the compounds of arsenic which have given rise to poisoning.*

Arsenic trioxide; potassium arsenite (Fowler's solution); sodium arsenite; various arsenical greens, sulphides; elementary arsenic.

310. *In what way may the arsenical greens give rise to accidental poisoning?*

By inhabiting rooms the walls of which are covered with paper colored by these substances; by the use of articles of clothing or ornament dyed with them, and by sucking ornamental confectionery of a green color.

311. *Have fatal cases of arsenical poisoning resulted from the external application of arsenical compounds?*

Yes, numerous cases are recorded resulting from the rubbing of arsenical preparations into the scalp, scrotum, etc., to kill parasites, as well as by the use of such preparations by quacks as cancer cures.

312. *What should the treatment be in arsenical poisoning?*

If vomiting have not occurred it should be induced by tickling the fauces or by zinc sulphate, never by tartar emetic; the stomach pump should never be used unless the case is seen very early. Moist, recently prepared ferric hydrate, or better, "dialyzed iron," should be administered.

313. *How is ferric hydrate prepared for this purpose?*

Add to solution of ferric sulphate (liq. ferri tersulphatis, U. S. P.) excess of aqua ammoniæ, collect upon a filter and wash with water. It should be prepared when wanted, and administered while still moist.

314. *Upon what is Marsh's test for arsenic based?*

Upon the following facts: 1st. When nascent hydrogen is in presence of an arsenical compound arseniuretted hydrogen is formed. 2d. When arseniuretted hydrogen is heated to redness it is decomposed into hydrogen and arsenic. 3d. When arseniuretted hydrogen is ignited, and a cold substance introduced into the flame, the oxidation does not proceed to the formation of arsenic trioxide, but elementary arsenic is deposited on the cold surface.

315. *How is Marsh's test conducted?*

Hydrogen is generated by the action of zinc on dilute sulphuric acid in a bottle, fitted with a funnel tube and connected by means of a right angle tube with a larger tube filled with plugs of asbestos; this in turn is connected with a piece of hard glass tube having a diameter of $\frac{1}{4}$ inch, drawn out at intervals of about 3 inches so as to reduce its

calibre to about $\frac{1}{8}$ inch, and terminating in a fine orifice. When the whole apparatus is filled with hydrogen the escaping gas is ignited, and the suspected fluid, freed from organic matter (see Q. 325), is poured in through the funnel tube. If arsenic be present the flame will increase in size, there will be an odor of garlic, while above the flame appears a white cloud more or less dense; if above the flame a cold test tube is held in an inverted position there will form upon its walls a white deposit, which, when examined with a magnifier, is found to consist of octahedral crystals. If a piece of cold porcelain be held near the point of the flame a dirty brownish stain of elementary arsenic is deposited upon it. The hard glass tube is now heated to redness at one of its wide parts, and if arsenic be present a shining, bluish-black, metallic-like deposit or "mirror" of arsenic is formed at the constriction beyond.

316. *What substance may be mistaken for arsenic by this test?*

Antimony, which under the same conditions produces stains and mirrors closely resembling those of arsenic.

317. *How may the two substances be distinguished?*

By applying the following tests:

1. Add to one of the stains a solution of ammonium sulphydrate (see Q. 430). If the stain be antimony, it dissolves rapidly; if arsenic, slowly.

2. Evaporate the solution obtained in 1. to dryness. Antimony gives a dark, orange red residue, while that of arsenic is bright yellow. The arsenic residue is soluble in aqua ammonia and insoluble in hydrochloric acid; the antimony residue

is insoluble in aqua ammonia, but soluble in hydrochloric acid.

3. Treat another stain with solution of "chloride of lime" (bleaching powder). If it be arsenic, it dissolves quickly; if antimony, it is not acted on.

4. Add to another stain nitric acid, warm and evaporate to dryness; to the white residue add solution of nitrate of silver. If the stain was due to arsenic, a brick-red color is produced; if to antimony, the residue remains white.

318. *What precautions are to be observed in applying Marsh's test?*

The apparatus must be new. The chemicals must be free from arsenic. To make sure of this the process must be tried in blank, with samples of the zinc and sulphuric acid to be used, and the tube heated for at least half an hour, and until the zinc has entirely disappeared. If the slightest stain has been produced, the chemicals must be rejected. The operation must be conducted in a well-ventilated locality, and care must be had not to inhale the gas formed, which is the very poisonous arseniuretted hydrogen. In adding the suspected fluid, only a small quantity must be used at first, lest, owing to the presence of a very large quantity of arsenic, so much arseniuretted hydrogen is formed that a portion escapes decomposition, and is thus not only lost, but may also produce unpleasant effects upon the operator. Collect as many stains and mirrors as possible.

319. *What is the chief difficulty in the use of this test?*

The difficulty of obtaining zinc and sulphuric acid free from arsenic. All commercial sulphuric

acid and most samples of zinc contain arsenic. The difficulty may be partially obviated by using magnesium in place of zinc, the former metal not being so liable to contain arsenic.

320. *Describe Reinsch's test for arsenic.*

Add to the suspected fluid one-sixth its volume of pure hydrochloric acid ; suspend in the fluid a piece of bright electrotype copper and boil. If arsenic be present, a steel gray deposit forms on the copper.

321. *What precautions are to be observed in this test?*

Be sure of the purity of the copper and hydrochloric acid used ; boil a strip of the copper in the acid diluted with five volumes of distilled water for at least half an hour to test them. Use only a small piece of copper at the beginning, when a deposit has formed on that remove it and substitute another, and so on until all the arsenic present has been collected. Do not conclude that arsenic is absent until the boiling has continued half an hour.

322. *What other substances produce deposits similar to those of arsenic, and how may they be distinguished?*

Antimony, mercury, and bismuth. Remove the copper with its adhering deposit, wash it with pure water, and dry between folds of filter paper, being careful not to rub off the deposit. Coil up the copper and put it into a clean, dry tube, open at both ends, holding the tube at such an angle that the spiral does not slip out ; apply heat at the part containing the copper. If the deposit be arsenic, there will form in the cold part of the tube a white deposit composed of small octahedral

crystals of arsenic trioxide; if antimony, a white sublimate will form, but it will have no crystalline appearance; if bismuth, no sublimate will be formed; and if mercury, there will form a deposit of metallic mercury in small brilliant globules.

323. *When is Reinsch's test not applicable?*

When arsenic is present in the form of arsenic acid or an arseniate; in this case the deposit is not formed at all, or only with great difficulty; when it is suspected that the substance present is an arseniate, it should be reduced to an arsenite by sulphurous acid before applying Reinsch's test. The test cannot be applied in the presence of oxidizing agents, such as free nitric acid, potassium chlorate, nitrates in large quantity, etc. On the other hand, this test is the only one that can be applied to fluids containing organic matter.

324. *What reaction takes place when sulphuretted hydrogen is passed through alkaline and acid solutions containing arsenic?*

If the solution be alkaline it becomes yellow, if acid a precipitate of yellow arsenic trisulphide is formed.

325. *What treatment must organic fluids be subjected to before testing for mineral poisons?*

The organic matter must be destroyed, as it interferes with the reactions to such an extent that in fluids containing organic matter it is impossible to be certain of the presence or absence of poisonous mineral matter. (See Appendix C.)

ANTIMONY.

326. *What are the symbol and atomic weight of antimony?*

Sb (from the Latin Stibium). 122.

327. *What are its physical properties?*

It has a metallic appearance, crystalline texture, is tasteless, odorless, brittle, and easily pulverized; it melts at 450°, and crystallizes on cooling; it may be distilled unchanged when air is excluded, but when sufficiently heated in air it burns brilliantly.

328. *What is the chief ore of antimony?*

The trisulphide, Sb_2S_3, known commercially as *black antimony* or *crude antimony*, and pharmaceutically as antimonii sulphuretum, U. S. P.

329. *For what purposes is antimony used in the arts?*

It enters into the composition of a number of important alloys: type-metal is an alloy of lead, tin, and antimony; britannia metal and the various antifriction alloys contain antimony. Its value in these alloys is, that it renders them hard and communicates the property of expanding on solidifying.

330. *What compound of antimony and hydrogen is known, and what are its properties?*

Antimoniuretted hydrogen, or hydrogen antimonide, SbH_3, having a composition corresponding to the hydrogen compounds of phosphorus and arsenic; it is a colorless gas, resembling arseniuretted hydrogen in its properties and decompositions.

331. *What is butter of antimony, and what are its physical properties?*

It is the trichloride, $SbCl_3$, and forms at ordinary temperatures a semi-solid, yellow, crystalline mass, which melts at 72° and boils at 223°; when exposed to the air it absorbs moisture and becomes first cloudy, then dark and oily.

332. *What is the action of water upon antimony trichloride?*

When diluted with a large quantity of water it is decomposed, and a white, insoluble precipitate is formed; this was formerly known as powder of Algaroth, and is a mixture of trichloride and trioxide of antimony.

333. *How is the antimonii oxidum, U. S. P., prepared?*

By washing the precipitate obtained in the last reaction and treating it with sodic carbonate in solution the remaining trichloride is decomposed, and there remains antimony trioxide as an odorless, tasteless, yellowish-white powder.

334. *What substance is formed when sulphuretted hydrogen is passed through a solution of an antimonial compound?*

Pentasulphide of antimony, Sb_2S_5; this is the "golden sulphuret of antimony."

335. *What is Kermes mineral?*

A mixture in varying proportions of the sulphides and trioxide of antimony, known pharmaceutically as antimonii oxysulphuretum, U. S. P.

(See Q. 800–802.)

BISMUTH.

335*a*. *What are the symbol and atomic weight of bismuth?*

Its symbol is Bi; its atomic weight, 210.

336. *What are its physical properties?*

A white, metallic substance, having peculiar reddish and greenish reflections; very brittle; melts at 268°; expands considerably on cooling; crystallizes in cubes; forms alloys with metals, some of which are fusible at very low temperatures.

337. *How is bismuth purified for use in pharmacy, and what is the object of the purification?*

Commercial bismuth is almost always contaminated with arsenic, to separate which it is fused with about one-fifth its weight of potassium nitrate.

338. *What is the action of nitric acid on bismuth?*

When bismuth is treated with nitric acid it is dissolved, brown fumes being given off; on cooling, white crystals of bismuth nitrate, $(NO_3)_3Bi$, form.

339. *What is the action of water upon bismuth nitrate?*

When the above solution is diluted with water a white precipitate is formed; this is bismuthyl nitrate, or a nitrate of the group (BiO) which behaves as an atom of an univalent metal:

$$\underset{\text{Bismuth nitrate.}}{(NO_3)_3Bi} + \underset{\text{Water.}}{H_2O} = \underset{\text{Bismuthyl nitrate.}}{NO_3(BiO)} + \underset{\text{Nitric acid.}}{2NO_3H}$$

This new substance is what is known as subnitrate of bismuth, bismuthi subnitras, U. S. P. The process by which this salt is prepared pharmaceu-

tically is more complicated, the object being the separation of arsenic.

340. *What are the so-called* oxysalts *or* subsalts *of bismuth?*

They are salts of the group $(BiO)'$, bismuthyl, which always behaves as an atom of an univalent metal; thus, we have:

Bismuth chloride—$BiCl_3$.
" bromide—$BiBr_3$.
" nitrate—$(NO_3)_3Bi$.
" sulphate—$(SO_4)_3Bi_2$.
" carbonate—$(CO_3)_3Bi_2$.
Bismuthyl chloride—$(BiO)Cl$.
" bromide—$(BiO)Br$.
" nitrate—$NO_3(BiO)$.
" sulphate $(SO_4)(BiO)_2$.
" carbonate—$(CO_3)(BiO)_2$.

341. *By what tests may bismuth be recognized?*

1. In an acid solution, sulphuretted hydrogen produces a black precipitate.

2. When a concentrated acid solution of a bismuth compound is diluted with water a white precipitate (a bismuthyl compound) is formed, which is insoluble in solution of tartaric acid.

3. When an alkali is added to a solution of a bismuth salt, a white precipitate, insoluble in excess of the reagent, is formed.

BORON.

342. *What are the symbol, atomic weight, and valence of boron?*

Its symbol is B; its atomic weight, 11. It is trivalent.

343. *What is the most important compound of boron?*

Boracic acid—BO_2H_3.

344. *What are the properties of boracic acid?*

White, glistening plates, unctious to the touch; odorless; having a slightly bitter taste, and without corrosive or poisonous action; soluble in water.

CARBON GROUP OF ELEMENTS.

Carbon	C	12
Silicium	Si	28
Titanium	Ti	50
Zirconium	Zr	89.5
Tin	Sn	118
Thorium	Th	234

CARBON.

345. *What are the symbol, valence, and atomic weight of carbon?*

Its symbol is C, it is quadrivalent, and its atomic weight is 12.

346. *How does carbon exist uncombined in nature?*

In three distinct allotropic forms: 1. Almost pure, crystallized, as diamond. 2. Nearly pure, but less so than in diamond, as graphite or "black lead." 3. Mixed with more or less impurity, as the various kinds of coal.

347. *Name some of the artificial products composed almost entirely of carbon.*

1. Charcoal, obtained by subjecting wood to heat, with a limited supply of air. 2. Lampblack, obtained by the incomplete combustion of substances rich in carbon, such as resin, etc. 3. Coke,

a porous substance remaining after heating certain kinds of coal, without contact with air. 4. Animal charcoal, obtained by subjecting animal matter to heat in closed vessels; contains a large amount of mineral salts or ash.

348. *What is the action of oxygen upon carbon at high temperatures?*

The two elements have a great tendency to unite with each other with liberation of heat and light; if the supply of oxygen be sufficient an invisible compound, having the composition CO_2, is formed, while if the supply of oxygen be insufficient a gas, CO, is formed.

349. *What are the compounds of carbon with other elements called?*

Organic substances.

(For compounds of carbon see pp. 145 et seq.)

SILICIUM.

350. *What are the symbol, atomic weight, and valence of silicium?*

Its symbol is Si; its atomic weight 28; it is quadrivalent.

351. *Name some important compounds of silicium.*

Silicic anhydride, or silicium dioxide, SiO_2, and the corresponding acid, SiO_4H_4.

352. *How do these substances exist in nature?*

They are very abundant. Silicic anhydride exists nearly pure as rock crystal, and less pure in the quartz entering into the composition of various rocks, sand, sandstone, and in a vast number of minerals. Silicic acid in combination, *i. e.*, silicates,

constitutes a great number of minerals, and exists in animal and vegetable bodies and in many mineral waters.

TIN.

353. *What are the symbol, atomic weight, and valence of tin?*

Its symbol is Sn. (Latin—Stannum); its atomic weight is 118. It forms two series of compounds, in one of which it is divalent and in the other quadrivalent.

354. *For what purposes is tin used in the arts?*

1. For protecting iron from the action of air and moisture; the various "tin" articles used in the household are made of iron covered with a thin layer of tin. 2. For manufacturing tin foil (see Q. 490). 3. In the silvering of looking-glasses.

355. *How may tin be reduced to powder?*

By pouring melted tin into a wooden box, whose inner surface has been covered with chalk, and shaking until it has cooled sufficiently to solidify.

356. *What are meant by* stannous *and* stannic *compounds?*

Those compounds of tin in which that element is divalent are called stannous; $SnCl_2$=stannous chloride; those in which it is quadrivalent are called stannic; $SnCl_4$=stannic chloride.

357. *How is stannous chloride obtained, and what are its uses?*

By dissolving tin in hydrochloric acid with the aid of gentle heat. It is a strong reducing agent, and is used in calico printing, and in the laboratory as a reagent for gold and mercury.

ELEMENTS OF THE HYDROGEN GROUP.

Hydrogen	H	1
Lithium	Li	7
Sodium	Na	23
Potassium	K	39
Rubidium	Rb	85.3
Cæsium	Cs	133
Silver	Ag	108

Note.—The grouping of the elements is based upon their valence and upon the nature of their compounds, and not upon any particular reaction; in the case of those elements usually called metals this classification is more difficult than with those sometimes called metalloids, as many of the former are exceedingly rare, and their chemistry has been only imperfectly studied. The distinction between metals and metalloids is one which cannot be adhered to, as it is impossible to draw the line of demarcation between them.

358. *What is the valence of the elements of this group?*

They are univalent.

LITHIUM.

359. *What are the symbol and atomic weight of lithium?*

Its symbol is Li; its atomic weight 7.

360. *How does it exist in nature?*

Always in combination, never in large quantities, but very widely diffused, especially in vegetables and in mineral waters. (See Q. 873.)

POTASSIUM.

361. *What are the symbol and atomic weight of potassium?*

Its symbol is K (Latin—Kalium); its atomic weight is 39.

362. *What are the physical properties of potassium?*

A silver white, metallic body; soft at ordinary temperatures, melts at 62°, and at a red heat boils, with formation of green vapors. It is lighter than water.

363. *What is the action of potassium on water and air?*

Potassium decomposes water with great energy:

$$K_2 + 2H_2O = 2KHO + H_2$$

Potassium. Water. Potassium hydrate. Hydrogen.

The action is so violent that flame and a slight explosion are produced; K has also a great tendency to unite with oxygen, and, if this be perfectly dry, potassium oxide, K_2O, is formed. When potassium is exposed to air its surface is rapidly coated with a yellowish white layer of KHO. In order to preserve the metal it must be kept under some substance containing no oxygen, as benzine.

364. *What is the constitution of potassium hydrate?*

It is a molecule of water in which one atom of

hydrogen has been replaced by one atom of potassium.

$$2\begin{matrix}H'\\H'\end{matrix}\Big\}O'' + \begin{matrix}K\\K\end{matrix}\Big\} = 2\begin{matrix}K\\H\end{matrix}\Big\}O + \begin{matrix}H\\H\end{matrix}\Big\}$$

2 Molecules Water. | 1 Molecule Potassium. | 2 Molecules Potassium hydrate. | 1 Molecule Hydrogen.

or, in other words, it is a molecule composed of one atom of the divalent oxygen united with one of each of the univalent atoms, hydrogen and potassium.

365. *Under what other names is potassium hydrate known?*

Caustic potash; potassa, U. S. P.; potassa fusa; potassa alba.

366. *What are the physical properties of KHO?*

It is a hard, white solid (usually in the shape of sticks, about one-quarter inch in diameter and six inches long), opaque, brittle; melts at a dull red heat; very soluble in water, less so in alcohol. Has a strong, soapy taste, even in dilute solution.

367. *Why should KHO and its solutions be protected from air?*

Because they rapidly absorb carbonic anhydride, forming potassium carbonate, and in course of time the hydrate will be entirely replaced by the carbonate.

368. *State some of the chemical properties of KHO?*

It is a powerful base, entering readily into reaction with acids to form salts:

$$\begin{matrix}K\\H\end{matrix}\Big\}O + \begin{matrix}NO_2\\H\end{matrix}\Big\}O = \begin{matrix}H\\H\end{matrix}\Big\}O + \begin{matrix}NO_2\\K\end{matrix}\Big\}O$$

Potassium hydrate. | Nitric acid. | Water. | Potassium nitrate.

It has a strong alkaline reaction and is a powerful caustic, dissolving most animal tissues; in concentrated solution it attacks glass; its solution dissolves sulphur, phosphorus, chlorine, bromine, and iodine, forming with these elements compounds soluble in water.

369. *What is the action of KHO on ammonium salts?*

Being a stronger base than ammonium it decomposes the ammoniacal salt with formation of a potassium salt, water, and ammonia:

$$NO_3(NH_4) + KHO = NO_3K + NH_3 + H_2O$$

Ammonium nitrate. Potassium hydrate. Potassium nitrate. Ammonia. Water.

370. *What is the action of solution of KHO on solutions of most metallic salts?*

It decomposes the salt with formation of the corresponding potassium salt and a metallic hydrate:

$$SO_4Cu + 2KHO = SO_4K_2 + CuH_2O_2$$

Cupric sulphate. Potassium hydrate. Potassium sulphate. Cupric hydrate.

Some of the hydrates being of characteristic color and insoluble in water, solution KHO is used as a test reagent. (See Q. 442, 520, 569.)

371. *What is the strength of liquor potassæ, U. S. P.?*

58 grams. KHO in 1 litre of water.

372. *What is potassa cum calce, U. S. P.?*

Equals parts of KHO and lime intimately mixed together; the object being to mitigate the caustic action of the potassa. Also known as Vienna caustic; milder common caustic.

373. *What is the action of KHO when taken internally?*

It acts as a powerful corrosive and probably also as a true poison.

374. *What antidotes should be used?*

The object being to neutralize the basic properties of the potash as rapidly as possible, some dilute acid, such as vinegar, is indicated. Substances, such as olive oil or milk, containing fats which form soaps with potash, may be given, but their action is not as rapid as that of an acid. The same objection to the use of the stomach pump applies here as in the case of the mineral acids. (See Q. 122.)

375. *What is the composition of potassium chloride, and where does it exist in nature?*

KCl. It is very widely distributed in mineral, vegetable, and animal nature, but does not exist anywhere in large quantity. It is found in all animal tissues and fluids, accompanying the corresponding sodium compound, but in much less quantity; it is most abundant in the red blood corpuscles.

376. *What are the composition and physical properties of potassium bromide?*

KBr. It forms milk-white cubes, containing no water of crystallization; unaltered by exposure to air; odorless, having a peculiar salty taste. Soluble in 1½ parts of cold water, and easily soluble in alcohol.

377. *How much bromine is contained in* 100 *parts KBr, and how is this ascertained?*

The molecule of KBr is composed of one atom of potassium, weighing 39, and one atom of bromine,

weighing 80; the weight of the molecule is therefore 39 + 80 = 119; obviously, 119 parts by weight of KBr contain 80 parts by weight of Br, and by the proportion

$$119 : 100 : : 80 : x$$

we find that 100 parts by weight of KBr contain 67.23 parts by weight of Br. (See Q. 11, 13, 14.)

378. *What is the action of chlorine upon KBr?*

It decomposes it with formation of the chloride and liberation of bromine:

$$Cl_2 + 2KBr = 2KCl + Br_2$$

Chlorine. Potassium bromide. Potassium chloride. Bromine.

379. *What reaction takes place between solutions of KBr and those of mercurous, lead, or silver salts?*

The bromine unites with the mercury, lead, or silver to form corresponding bromides, which are insoluble. With solution of mercuric chloride (corrosive sublimate) it gives no precipitate, if it do the bromide is contaminated with potassium iodide.

380. *What are the composition and physical properties of potassium iodide?*

KI. It forms milk-white cubes without water of crystallization; odorless, having a sharp, bitterish, saline taste; unaltered by exposure to air (when it becomes damp it is impure). Very soluble in water, less so in alcohol; the solutions being clear, colorless, and neutral.

381. *How may the purity of KI be tested?*

Its solution should not have an alkaline reaction and should not effervesce upon the addition of an acid (alkaline carbonates); when acidulated with pure HCl it should give no precipitate with barium

chloride, and the fluid should remain clear when neutralized with aqua ammoniæ (sulphates and phosphates); when acidulated with pure, dilute hydrochloric acid and shaken with chloroform, the latter should not be colored (iodates).

382. *Why is KI incompatible with the insoluble mercurials?*

Because it renders them soluble to a greater or less extent, and consequently much more active.

383. *When solutions of mercuric chloride (corrosive sublimate) and KI are brought together, what is formed?*

Mercuric iodide HgI_2, or red iodide of mercury.

384. *What takes place when KI and metallic salts are combined?*

The formation of the potassium salt of the acid and an iodide of the other metal.

$$\underset{\text{Lead acetate.}}{(C_2H_3O_2)_2Pb} + \underset{\text{Potassium iodide.}}{2KI} = \underset{\text{Potassium acetate.}}{2C_2H_3O_2K} + \underset{\text{Lead iodide.}}{PbI_2}$$

This reaction is important in the cases of lead, bismuth, copper and silver.

385. *What is the action of chlorine, bromine, or fuming nitric acid upon KI?*

The salt is decomposed with liberation of free iodine.

386. *Why is potassium chlorate incompatible with KI?*

Solutions of these two substances do not act upon each other ordinarily, but the presence of a small quantity of a free mineral acid provokes the decomposition of the iodide with liberation of iodine. The free acid is supplied by the gastric juice.

387. *What is potassii sulphuretum, U. S. P.?*

A mixture, in varying proportions, of the potassium salts of several sulphur acids with several sulphides of potassium and potassium carbonate. It forms a brown, shapeless mass, having an odor of sulphuretted hydrogen, and sometimes known as "liver of sulphur."

388. *What is Javelle Water?*

A solution of potassium hypochlorite, ClOK; a compound which is only known in solution, and is formed by passing chlorine through a cold solution of potassium carbonate. It is a clear, colorless liquid, having an odor of chlorine and a bleaching action upon vegetable colors. It is used in removing stains from fabrics.

389. *What are the formula and physical properties of potassium chlorate?*

ClO_3K.—Occurs in transparent, colorless plates, without water of crystallization; permanent in air; odorless; has a cool, salty taste; soluble in 30 parts of cold water; sparingly soluble in alcohol. Its aqueous solution is colorless and neutral in reaction.

390. *What decomposition does ClO_3K undergo when heated?*

It first fuses, and at higher temperatures is decomposed, yielding oxygen and potassium chloride:

$$\underset{\text{Potassium chlorate.}}{2ClO_3K} = \underset{\text{Potassium chloride.}}{2KCl} + \underset{\text{Oxygen.}}{3O_2}$$

This is the reaction generally utilized for the production of oxygen.

391. *What precaution is to be had in dispensing ClO_3K?*

It should never be combined with any organic or easily oxidizable substance, or with any strong acid or acid sulphate. With these substances ClO_3K is readily decomposed, forming substances which are violently explosive.

NOTE.—It is safest only to use this compound in simple aqueous solution, as the formation of these explosive substances frequently occurs under imperfectly studied conditions. The manufacture of chlorate of potassium lozenges is a dangerous operation, and disastrous explosions have been traced to it.

392. *How many possible sulphates of potassium are there, why and what are they called?*

There are two. Sulphuric acid being a dibasic acid, and potassium an univalent metal, there may be one compound in which one atom of hydrogen is replaced by one atom of potassium, and another in which both atoms of hydrogen are so replaced:

SO_4H_2=Sulphuric acid.

SO_4HK=Hydro-potassic sulphate.
SO_4K_2=Potassic sulphate.

393. *By what other names is hydro-potassic sulphate known?*

Bisulphate of potassium, or acid sulphate of potash; formerly called sal enixum.

394. *By what other names is potassic sulphate known?*

Potassæ sulphas, U. S. P.; sulphate of potash; vitriolated tartar; sal de duobus.

395. *Where does SO_4K_2 exist in nature?*

In solution in many waters; in small quantity in plants; in nearly all animal tissues and fluids, most abundant in urine.

NOTE.—It is probable that some of this substance found in the urine is produced in the economy by the oxidation of the sulphur entering into the composition of albuminoid substances.

396. *What are the properties of SO_4K_2?*

It crystallizes in hard, white prisms, permanent in air; odorless; having a bitter, salty taste; sparingly soluble in water.

397. *What are the formula and common names of potassium nitrate?*

NO_3K. Potassæ nitras, U. S. P.; saltpetre, nitre.

398. *What is the origin of NO_3K?*

It has its origin in the oxidation of animal or vegetable substances rich in nitrogen, in the presence of potassium. It is thus formed both naturally and artificially. The commercial salt is usually very impure.

399. *What are the chief uses of NO_3K?*

In the manufacture of nitric and sulphuric acids, and of gunpowder; in packing beef and pork. In the laboratory it is used as an oxidizing agent.

400. *How many phosphates of potassium are there, and how are they designated?*

There are three:

PO_4H_3—Phosphoric acid.

PO_4H_2K—Dihydro-potassic phosphate.
PO_4HK_2—Hydro-dipotassic "
PO_4K_3—Tripotassic "

401. *What is PO_4H_2K sometimes called, and in what animal fluids is it found?*

Acid potassium phosphate. It occurs in the juice of muscular tissue and in the urine. It is to the presence of this substance that the urine owes its acid reaction.

402. *What is PO_4HK_2 sometimes called, and where does it exist in the economy?*

This and the corresponding sodium compound are known as alkaline phosphates; they are found together in all parts of the animal economy, and in greater quantity in the carnivora than in the herbivora.

403. *What important function do these salts perform in the circulating fluids?*

That of maintaining an alkaline reaction.

404. *How are phosphates produced in the economy?*

By the oxidation of the phosphorus entering into the composition of organic substances called lecithins, which exist principally in nerve tissue.

405. *What are the analytical characters of the potassium compounds?*

They are nearly all soluble and colorless, unless the acid be colored. With platinic chloride a yellow, crystalline precipitate, which is very sparingly soluble in water, is formed. Hydrofluosilicic acid produces a gelatinous, opalescent precipitate. In concentrated solution tartaric acid produces a crystalline precipitate. They color the flame of a Bunsen burner violet; if sodium be present this color is masked. Potassium compounds are distinguished from those of ammonium, which also give a pre-

cipitate with platinic chloride, by the fact that they are not volatile at a red heat.

(For other potassium compounds see corresponding acids.)

SODIUM.

406. *What are the symbol and atomic weight of sodium?*

Its symbol is Na (Latin, Natrium); its atomic weight 23.

407. *What are the physical properties of elementary sodium?*

When pure it is a soft, grayish-white solid, having a metallic lustre, and crystallizing in cubes; lighter than water (sp. gr. 0.972). A good conductor of heat and of electricity.

408. *What is the action of sodium on water?*

If a fragment of sodium be thrown upon water it floats upon the surface, and gradually disappears, with a hissing noise, while hydrogen is given off, and caustic soda is formed:

$$\underset{\text{Sodium.}}{2Na} + \underset{\text{Water.}}{2H_2O} = \underset{\text{Sodic hydrate.}}{2NaHO} + \underset{\text{Hydrogen.}}{H_2}$$

The tendency of sodium to decompose water in this way, and also to unite with oxygen, is so great that it can be kept only in media free from oxygen, as benzine; if it be exposed to air it is immediately tarnished by the formation of a white substance which is Na_2O if the air be dry, and NaHO if it contain moisture.

409. *What is common salt?*

Sodium chloride; NaCl.

410. *What are the chief impurities present in common salt?*

Chlorides of calcium and of magnesium.

411. *In what parts of the animal economy is NaCl found?*

In all parts.

412. *What functions does it perform?*

It aids the absorption of albuminoid substances and the phenomena of osmosis throughout the body. It is also more than probable that the hydrochloric acid of the gastric juice has its origin in the decomposition of this salt.

413. *How is it eliminated?*

With all the excretions, principally by the kidneys.

414. *What are the chief uses of NaCl in the arts?*

As a starting-point in the manufacture of most of the sodium compounds, hydrochloric acid, chlorine, bleaching powder; in the preservation of meats, fish, etc., and in glazing pottery.

415. *What data are required to calculate the quantity of bromine in* 100 *parts of sodium bromide?*

1st. Its formula—NaBr. 2d. The atomic weight of sodium—23 and that of bromine—80; the sum being of course the molecular weight of NaBr= 103. 3d. Whether or no the substance in the condition used contains water of crystallization or not.

NOTE.—This last point must not be lost sight of. NaBr contains no water of crystallization, and if we weigh out 103 parts, we will have 80 parts Br.; but suppose it contained 1 molecule of water of crystallization, its formula would then be NaBr+ Aq, and to get 80 parts Br we would have to take 23+80 +2+16=121 parts.

416. *Calculate how much iodine there is in* 100 *parts of sodium iodide.*

Its formula is NaI, and it contains no water of crystallization; its molecular weight is, therefore, $23+127=150$, or 150 parts NaI contain 127 parts I. Therefore:

$$150 : 100 :: 127 : x \qquad x=84.66$$

417. *What are the chemical name and formula of caustic soda?*

Sodium hydrate—NaHO.

418. *What is the strength of Liquor sodæ, U. S. P.?*

57 grams to the litre; its sp. gr. is 1.071.

419. *In what pharmaceutical preparation does sodium hypochlorite exist?*

In liquor sodæ chlorinatæ, also known as Labarraque's solution, a clear, colorless fluid, having an odor of chlorine; used as a disinfecting agent.

420. *What are the principal uses of sodium hyposulphite?*

It is largely used in photography to dissolve bromide, iodide, and chloride of silver. It is also used medicinally for its power of destroying the lower forms of vegetable life (ferments).

421. *What sodium salts of sulphuric acid are known?*

Two. Hydro-sodic sulphate SO_4HNa and
Sodic sulphate SO_4Na_2.

422. *Under what common names is sodic sulphate known?*

Sodæ sulphas, U. S. P.; sulphate of soda; Glauber's salt; vitriolated soda; neutral sulphate of soda.

423. *Give the formula and synonyms of sodium nitrate.*

NO_3Na. Chili saltpetre; cubic nitre; sodæ nitras, U. S. P.

424. *What are the chemical name and formula of sodæ phosphas, U. S. P.?*

Hydro-disodic phosphate; PO_4HNa_2.

425. *Give the analytical reactions of sodium.*

All the usual salts of sodium are soluble in water; the only reagent producing a precipitate in solutions of sodium compounds is potassium pyroantimoniate. The salts of sodium may be distinguished from those of ammonium by not being volatile when heated; and from those of potassium by not yielding precipitates with platinic chloride or tartaric acid. Sodium gives a yellow color to the Bunsen flame, which, when examined with the spectroscope, shows a double yellow line corresponding to the Fraunhofer line *D* in the solar spectrum. This reaction is so delicate that the line is seldom absent, owing to particles of NaCl in the air.

AMMONIUM.

426. *What is the ammonium theory?*

The ammoniacal compounds, such as sal ammonic, are not compounds of ammonia gas, but of a group of atoms (NH_4) called ammonium. This group behaves like an atom of an univalent metal, such as potassium; as potassium chloride has the formula KCl, so ammonium chloride has the formula $(NH_4)Cl$. Liquor ammoniæ is not a simple solution of ammonia gas in water; it contains a true ammonium hydrate $(NH_4)HO$, corresponding

in all respects to the hydrates of potassium and sodium, KHO and NaHO, except that upon being heated it is decomposed into ammonia gas and water:

$$\underset{\text{Ammonium hydrate.}}{(NH_4)HO} = \underset{\text{Ammonia.}}{NH_3} + \underset{\text{Water.}}{H_2O}$$

Ammonium has not yet been obtained in a free state with certainty, but an amalgam may be readily obtained, corresponding to the amalgams of sodium and potassium, and containing NH_4Hg. (See Q. 531.)

427. *State the formula and common names of ammonium chloride.*

$(NH_4)Cl$. Ammoniæ murias, U. S. P.; sal ammoniac.

428. *What are the properties of NH_4Cl?*

It forms long, prismatic, fibrous crystals, which are tough and flexible; colorless; odorless; having a sharp, salty taste, permanent in air, and, like all ammonium compounds, entirely volatilized by heat; soluble in three parts of cold water, and not much more soluble in warm water. Its solution is neutral, but when boiled is partly decomposed, losing ammonia and becoming acid. When in contact with free chlorine and water, the exceedingly explosive chloride of nitrogen is formed.

429. *What are the sources of the ammoniacal compounds?*

From stale urine; as a bye product in the manufacture of bone black; from the "ammoniacal liquor" obtained in manufacturing illuminating gas; this is distilled, and the distillate passed into

hydrochloric or sulphuric acid, when ammonium chloride or sulphate is formed.

430. *How is ammonium sulphydrate prepared?*

By passing sulphuretted hydrogen through a solution of ammonium hydrate :

$$\begin{matrix} H \\ H \end{matrix}\Big\} S + \begin{matrix} (NH_4) \\ H \end{matrix}\Big\} O = \begin{matrix} (NH_4) \\ H \end{matrix}\Big\} S + \begin{matrix} H \\ H \end{matrix}\Big\} O.$$

Hydrogen sulphide. Ammonium hydrate. Ammonium sulphydrate. Water.

431. *What are the properties and uses of the solution thus obtained?*

When freshly prepared, it is a colorless liquid, having the odor of ammonia, as well as that of sulphuretted hydrogen ; when old it assumes a yellow color. It is a valuable reagent in analysis.

432. *State the analytical reactions of the ammonium compounds.*

They are all entirely volatile on the application of heat. When heated with potash solution ammonia gas is given off ; this restores the blue color to moist, reddened litmus paper, the red color returning when the paper is warmed. A glass rod, moistened with hydrochloric acid and held over the warm, mixed solutions of potash and an ammoniacal compound, gives off a white cloud of $(NH_4)Cl$. Solutions of ammoniacal compounds form precipitates with platinic chloride and with tartaric acid.

SILVER.

433. *Give the symbol and atomic weight of silver.*

Its symbol is Ag. (Latin, argentum) ; its atomic weight, 108.

434. *State the principal physical properties of silver.*

Of all metals, it is the whitest, the most lustrous, and takes the highest polish. It is the best known conductor of heat and of electricity; it is harder than gold, and softer than copper; it melts at 1000° C., and distils at the temperature of the oxy-hydrogen flame.

435. *Mention some of the chemical properties of silver.*

It is not oxidized in dry or moist air at any temperature; if the air contain traces of sulphuretted hydrogen or of sulphur dioxide, the surface of the metal becomes tarnished by the formation of the black silver sulphide. It is attacked at ordinary temperatures by Cl, Br, I, and S, with formation of corresponding compounds. It is not attacked even at high temperatures by the caustic or carbonated alkalies; silver vessels are therefore used in the laboratory for heating these substances, which act upon glass, porcelain, and platinum. Silver acts readily upon nitric acid, with formation of silver nitrate; with boiling sulphuric acid, argentic sulphate is formed; with hydrochloric acid, a coating of the insoluble silver chloride forms upon the metal, and prevents further action.

436. *How is impure nitrate of silver obtained?*

By dissolving coin silver in nitric acid.

437. *With what substance is this contaminated?*

With nitrate of copper. Coin silver is an alloy of silver and copper, and the nitrates of both metals are formed.

438. *How is pure silver nitrate obtained?*

Add to the solution of the impure nitrate diluted

hydrochloric acid or a solution of common salt, the white insoluble silver chloride is deposited, this is collected upon a filter and washed with water until the filtrate no longer precipitates with a solution of nitrate of silver. The dried chloride is mixed with chalk and powdered charcoal (AgCl, 100 parts; chalk, 70 parts; charcoal, 5 parts), and the mixture thrown in small portions into a red hot crucible; upon cooling, a "button" of pure metallic silver is found at the bottom of the crucible; this is then dissolved in pure warm nitric acid, and the excess of acid is driven off by heat, the mass is then fused and stirred as long as brown fumes are given off, when it is allowed to cool, and, if desired in crystals, is dissolved in a small quantity of pure water and left to crystallize in the dark. The crystals are drained in a funnel plugged with asbestos, and preserved in opaque bottles.

NOTE.—A United States trade dollar should yield 595 grains pure NO_3Ag, the amount obtained is, however, usually somewhat less.

439. *What are the physical properties of silver nitrate?*

It crystallizes in transparent, colorless plates containing no water of crystallization; quite soluble in water, the solution being colorless and neutral if the excess of nitric acid have been driven off. When heated to dull redness it fuses, and, when allowed to solidify in small cylindrical moulds, forms a hard white amorphous mass, known as *lunar caustic; lapis infernalis; argenti nitras fusa, U. S. P.* If the heat be too great the nitrate is decomposed with formation of the sparingly soluble nitrite, or of metallic silver. When absolutely pure, NO_3Ag

is not affected by light, but if a very small quantity of organic matter be present it turns black.

440. *What action has nitrate of silver upon animal tissues?*

In contact with animal matter silver nitrate is rapidly decomposed, metallic silver being deposited and producing the characteristic black stain, while free nitric acid is liberated; it is to the liberation of this substance that lunar caustic owes its action as an escharotic.

441. *Mention some substances in common use containing silver nitrate.*

Certain kinds of black hair-dye, and the various indelible inks used for marking linen.

442. *How is silver monoxide obtained?*

When solution of potash is added to solution of silver nitrate an olive brown precipitate of silver hydrate, AgHO, is formed, this, upon being dried at 70°, loses water and is converted into silver monoxide:

$$\underset{\text{Silver hydrate.}}{2AgHO} = \underset{\text{Silver monoxide.}}{Ag_2O} + \underset{\text{Water.}}{H_2O}$$

443. *State the properties of silver monoxide.*

It is very readily decomposed into silver and oxygen, especially in the presence of certain organic substances. It is an energetic base. When digested with ammonium hydrate fulminating silver is formed, as a black powder.

444. *Give the analytical reactions of silver.*

When hydrochloric acid, or a soluble chloride is added to a solution of a silver compound, the insoluble silver chloride is formed as a white precipitate, insoluble in nitric acid, soluble in ammo-

nium hydrate, from which solution it is again precipitated by the addition of an acid.

445. *How may the chlorides of lead, mercury (ous), and silver be distinguished from each other?*

By the action of ammonium hydrate, which dissolves silver chloride, leaves lead chloride unchanged, and with mercurous chloride forms a black compound.

446. *What antidotes are to be used in poisoning by silver salts?*

Common salt; white of egg or milk, followed by an emetic.

ELEMENTS OF THE CALCIUM GROUP.

CALCIUM	Ca	40
STRONTIUM	Sr	87.5
BARIUM	Ba	137

447. *State the characteristics of elements of this group.*

They are divalent; their sulphates and carbonates are insoluble; their hydrates are known as the alkaline earths.

448. *How does calcium exist in nature?*

It does not occur in its elementary form, but in its compounds it is one of the most abundant of the elements. Its carbonate exists as chalk, marble, limestone, etc.; its sulphate is found in nature as gypsum and alabaster, while several other compounds exist in various minerals. Its compounds also enter into the composition of animal and vegetable tissues.

449. *Give the formula and common names of calcic monoxide.*

CaO. Calx, U. S. P.; calx viva; quicklime.

450. *State the method of its preparation and its properties.*

It is obtained by heating limestone, which is a native calcic carbonate, to about 800° C., at which

temperature it is decomposed; carbonic anhydride is given off, and calcic monoxide remains. It forms white masses, having the shape of the fragments of limestone used, but no crystalline structure. It is odorless; has a caustic, alkaline taste and alkaline reaction. When exposed to the air it absorbs water and carbonic anhydride, falling to a powder composed of a mixture of calcic carbonate and calcic hydrate; it is then said to be air slaked. It is infusible at any temperature yet attained.

451. *What takes place when calcic oxide is treated with water?*

When water is thrown upon quicklime a crackling sound is heard, much heat is liberated, the lime swells up, and a new substance, calcic hydrate, is formed:

$$\underset{\text{Calcic oxide.}}{CaO} + \underset{\text{Water.}}{H_2O} = \underset{\text{Calcic hydrate.}}{CaH_2O_2}$$

This is known as slaked lime, and is a light, white powder, odorless, having an alkaline taste and reaction. It is sparingly soluble in cold water, and less soluble in hot water. It absorbs carbonic anhydride readily from the air, forming calcic carbonate, which is again decomposed when heated.

452. *What are* lime-water *and* milk of lime?

The former is a solution of calcic hydrate in water; the latter is such a solution holding in suspension a great excess of calcic hydrate.

453. *What is Liquor calcis saccharatus, U. S. P.?*

A solution of calcic hydrate in water containing cane-sugar, the presence of the latter substance increasing very materially the solubility of calcic

hydrate; the preparation therefore contains much more lime than does lime-water.

454. *Give the formula and common names of calcium chloride.*

$CaCl_2$. Calcii chloridum, U. S. P.; muriate of lime.

455. *How is it obtained, and what are its prominent properties?*

It is formed whenever a calcium compound is acted upon by hydrochloric acid, and notably as a bye-product in obtaining carbonic anhydride.

$$\underset{\text{Marble.}}{CO_3Ca} + \underset{\text{Hydrochloric acid.}}{2HCl} = \underset{\text{Calcium chloride.}}{CaCl_2} + \underset{\text{Water.}}{H_2O} + \underset{\text{Carbonic anhydride.}}{CO_2}$$

It is odorless and has a sharp, salty taste. When fused and allowed to cool it forms a rough, amorphous mass, which absorbs water with great energy, and is therefore used in the laboratory as a drying agent.

456. *What is the difference between calcium chloride and chloride of lime?*

The former is a definite compound, $CaCl_2$, while the latter is a complex substance, probably a mixture containing calcium chloride, $CaCl_2$, and calcium hypochlorite.

457. *Under what other name is chloride of lime known, and what are its properties and uses?*

It is commonly known as bleaching-powder. The hypochlorite is very readily decomposed by acids with evolution of chlorine, which then acts as a powerful bleaching and disinfecting agent. When exposed to the air it is decomposed by the carbonic anhydride contained therein.

458. *What is gypsum?*

A native, crystalline calcium sulphate, containing two molecules of water of crystallization.

459. *Give the method of preparing plaster of Paris, and explain its use.*

It is prepared by subjecting gypsum to the action of heat, which drives off the water of crystallization; a white, opaque mass remains, which is then ground to a fine powder. This powder, when made into a paste with water, takes up two molecules of water of crystallization, and forms a hard mass, or "sets," as the term is; during this hardening process the mass expands and fills every part of the containing vessel, which permits of its use in making moulds and casts.

460. *What objection is there to the use of plaster in the ordinary way on walls of hospitals?*

It forms a coating which is porous and uneven. In these pores and upon the projections various deleterious organic substances collect to such an extent that by scratching the surface of plaster in a hospital, a powder has been obtained containing as much as 46 per cent. of organic matter.

461. *How may this defect be remedied?*

By adding to the ordinary mixture of plaster and water, used in plastering, a certain proportion of alum and gelatin. This mixture, on "setting," forms a hard surface, which is then polished, and may be rendered very smooth; it may also be washed as often as required with water containing a disinfecting agent, such as Liq. sodæ chlorinatæ.

462. *Give the chemical name and formula of bone phosphate.*

Tricalcic phosphate $(PO_4)_2Ca_3$.

463. *How does* $(PO_4)_2Ca_3$ *exist in the animal economy?*

It is the most abundant mineral ingredient of the body, and is found in every tissue and fluid, most abundantly in the bones and teeth; in the fluids it exists in small proportion, except in the milk where it is found in comparatively large quantity (about $2\frac{3}{4}$ parts per 1000). In the bones it is in combination with an organic substance, and upon the relative proportions of these two the rigidity and tenacity of the bone depends.

464. *How is "bone black" prepared, and what is its composition?*

It is obtained by subjecting bones to a red heat without access of air. It is composed of carbon, tricalcic phosphate and small quantities of other salts (calcic carbonate, trimagnesic phosphate and calcic fluoride). By treating it with dilute hydrochloric acid the mineral substances are removed, and "purified animal charcoal" remains.

465. *State the properties and uses of animal charcoal.*

It possesses, in a high degree, the power of absorbing coloring-matters and other substances from solutions. It is used in large quantities in the refining of cane-sugar to remove the coloring-matter, and for the same purpose in various pharmaceutical and chemical operations; care must be had, however, that loss be not sustained from the absorbing action of the charcoal on other substances, such as the alkaloids and various vegetable principles; indeed, purified animal charcoal has been used to separate alkaloids from solutions in which they are mixed with other substances. The

decolorizing power of the crude charcoal is greater than that of the purified; the latter is to be used in the presence of any substance capable of acting on the mineral ingredients of the crude charcoal, notably in the presence of acids.

466. *How may pure tricalcic phosphate be obtained?*

The impure salt, bone black, is acted on by hydrochloric acid when the soluble monocalcic phosphate and calcium chloride are formed:

$$\underset{\text{Tricalcic phosphate.}}{(PO_4)_2Ca_3} + \underset{\text{Hydrochloric acid.}}{4HCl} = \underset{\text{Monocalcic phosphate.}}{(PO_4)_2CaH_4} + \underset{\text{Calcium chloride.}}{2CaCl_2}$$

Ammonium hydrate is then added to the solution, when pure tricalcic phosphate (calcis phosphas præcipitata, U. S. P.) is precipitated, and ammonium chloride remains in solution.

$$\underset{\text{Monocalcic phosphate.}}{(PO_4)_2CaH_4} + \underset{\text{Calcium chloride.}}{2CaCl_2} + \underset{\text{Ammonium hydrate.}}{4(NH_4)HO} =$$

$$\underset{\text{Tricalcic phosphate.}}{(PO_4)_2Ca_3} + \underset{\text{Ammonium chloride.}}{4(NH_4)Cl} + \underset{\text{Water.}}{4H_2O}$$

467. *What is "superphosphate of lime?"*

An impure monocalcic phosphate, obtained by acting on bone-ash with sulphuric acid. It is used as a manure.

468. *In what parts of the body does monocalcic phosphate exist?*

In brain-tissue and in the acid fluids; in the urine. This salt and the corresponding magnesium compound are known as "earthy phosphates."

BARIUM.

469. *What compound of barium is used in analysis, and for what purpose?*

Barium chloride, $BaCl_2$, is used as a test for the presence of sulphuric acid or of a soluble sulphate; a white precipitate of barium sulphate, *insoluble in nitric acid*, is formed.

470. *What antidotes should be given in poisoning by the soluble barium compounds?*

Magnesium or sodium sulphate.

471. *Give the analytical reactions common to the compounds of calcium, barium, and strontium.*

They are colorless, unless the acid be colored; they form no precipitate with sulphuretted hydrogen or with ammonium hydrosulphide; they form insoluble precipitates with ammonium carbonate in alkaline solution.

472. *How may they be distinguished from each other?*

The calcium compounds, in dilute solution, form, with ammonium oxalate, a crystalline precipitate, soluble in hydrochloric acid but insoluble in ammonium hydrate; barium and strontium compounds form insoluble precipitates with solution of calcium sulphate; barium compounds color the Bunsen flame green, while those of strontium communicate a red color.

ELEMENTS OF THE LEAD GROUP.

Lead	Pb	207
Magnesium	Mg	24
Zinc	Zn	65.2
Cadmium	Cd	112
Indium	In	75.8

473. *What is the valence of elements of this class?*
They are divalent.

474. *Of how many atoms are the molecules of zinc and cadmium composed?*
Of one.

LEAD.

475. *What mineral is the most important ore of lead?*
A native sulphide, PbS, called galena; it frequently contains a considerable quantity of silver.

476. *Name some of the alloys into whose composition lead enters.*
Type-metal, pewter, Britannia metal, solder, shot. The last-named contains arsenic.

477. *What is the formula of lead monoxide, and under what other names is it known?*
PbO. Plumbi oxidum, U. S. P.; litharge; massicot.

478. *How is it prepared, and what are its principal properties?*

It is prepared by heating lead in a current of air; direct union of the lead and oxygen takes place, forming a yellow powder known as massicot; when heated to redness, this fuses, and, on cooling, forms coppery, crystalline scales, in which form it is known as litharge. Litharge should not be fused in an earthen crucible, as it combines with the silicic anhydride to form a fusible lead silicate, and thus perforates the crucible. Litharge is sparingly soluble in water; the solution absorbs CO_2 from the air, and lead carbonate is precipitated; it is also soluble in solutions of the hydrates of potassium, sodium, and calcium. It is a powerful base.

479. *For what purposes is PbO used in the arts?*

In the manufacture of glass, white lead, red lead, acetate of lead, for communicating a drying power to oils, in making the various plasters used in pharmacy. A solution of PbO in lime-water is used as a hair-dye, the lead, combining with sulphur from the hair, forms the black lead sulphide.

480. *Give the formula and other names of lead dioxide.*

PbO_2. Puce colored oxide of lead; peroxide of lead; plumbic anhydride.

481. *Why is the name plumbic anhydride given it?*

Because it is the anhydride of a weak acid, having the formula PbO_3H_2; although the acid has not been obtained, several of its salts are known, *e.g.*, PO_3K_2=potassium plumbate.

482. *How is red lead obtained, and under what other names is it known?*

Litharge is further oxidized by roasting it in contact with air. It is known as Plumbi oxidum rubrum, U. S. P.; red oxide of lead; minium.

483. *What is the composition of red lead?*

It has not a constant composition, being a mixture, in varying proportions, of two substances; one the lead salt of plumbic acid (see Q. 481), or lead plumbate, PbO_3Pb, and the other lead monoxide, PbO; it usually has the composition $PbO_3Pb + PbO$.

484. *What compound of lead with a mineral acid is soluble in water, and how is it obtained?*

The nitrate, $(NO_3)_2Pb$. It is formed by dissolving the oxides or carbonate of lead in nitric acid.

$$\underset{\text{Litharge.}}{PbO} + \underset{\text{Nitric acid.}}{2NO_3H} = \underset{\text{Lead nitrate.}}{(NO_3)_2Pb} + \underset{\text{Water.}}{H_2O}$$

485. *What are the uses of lead nitrate?*

It is used in preparing the iodide. It enters into the composition of many disinfecting fluids; Ledoyen's disinfectant is a solution of this substance of the strength of a dram to the fluid ounce.

486. *Give the formula of lead iodide, and its method of formation.*

PbI_2. It is obtained by adding solution of potassium iodide to solution of lead nitrate:

$$\underset{\substack{\text{Lead}\\\text{nitrate.}}}{(NO_3)_2Pb} + \underset{\substack{\text{Potassium}\\\text{iodide.}}}{2KI} = \underset{\substack{\text{Potassium}\\\text{nitrate.}}}{2NO_3K} + \underset{\substack{\text{Lead}\\\text{iodide.}}}{PbI_2}$$

487. *State the properties of lead iodide.*

It forms a lemon yellow powder, very sparingly soluble in cold water, more soluble in hot water, from which latter solution it separates in crystals; its solution is colorless.

488. *What is Turner's yellow, or Cassel yellow?*

A compound of chloride and monoxide of lead.

489. *Give the analytical reactions of lead.*

The soluble lead compounds have a sweetish, metallic taste. Sulphuretted hydrogen and the alkaline sulphides form a black precipitate, insoluble in ammonium hydrosulphide, but soluble in hot, fuming nitric acid. Sulphuric acid and sodium chloride form white precipitates; potassium chromate and potassium iodide form yellow precipitates.

490. *Give some of the prominent causes of lead-poisoning.*

The contamination of drinking water from lead pipes (see Q. 59, 60, 61). Contamination of articles of food or drugs by contact with leaden vessels, or from being enclosed in tinfoil containing an excess of lead. Drinking beer, cider, etc., which has been drawn through leaden pipes, or allowed to stand in pewter vessels. The ingestion or constant handling of lead compounds, as the acetate, nitrate, carbonate (white lead—painters' colic), Goulard's extract, etc. The use of hair-dyes containing lead.

491. *What is the best antidote in acute lead-poisoning?*

Magnesium sulphate, which brings about the formation of the insoluble lead sulphate, while the purgative action of the magnesia is also useful; it should be preceded by an emetic, or by the use of the stomach-pump.

MAGNESIUM.

492. *Give the properties of magnesium.*

It is a silver-white substance, having a metallic lustre, which it retains in dry air, but loses rapidly in moist air. It may be easily drawn out into wire or ribbon, it melts at 500° C., and distils, when protected from air, at a white heat. It decomposes hot water with formation of magnesium hydrate and liberation of hydrogen. When heated in air it burns brilliantly, the light emitted having great actinic power. It unites directly with chlorine, bromine and iodine.

493. *Give the formula and common names of magnesium oxide.*

MgO. Magnesia, U. S. P.; magnesia lævis; magnesia usta; calcined magnesia.

494. *State its properties.*

It is a very light (1 ounce fills a 4 ounce vial), amorphous, white powder; infusible: very sparingly soluble in water; in contact with water it is gradually converted into the hydrate, MgO_2H_2. When exposed to air it gradually absorbs water and carbonic anhydride. With nitric, sulphuric, or hydrochloric acid it forms the corresponding salt. (Effervescence denotes contamination with magnesium carbonate.)

495. *What is "milk of magnesia"?*

Magnesium oxide held in suspension in water (1 part MgO to 10-20 parts H_2O).

496. *Under what other names is magnesium sulphate known and what is its formula?*

Magnesiæ sulphas, U. S. P.; sulphate of magnesia; Epsom salts. SO_4Mg.

497. *Give the characters of SO_4Mg.*

It forms colorless transparent crystals, containing 7 molecules of water of crystallization. Easily soluble in water, the solution being neutral. Insoluble in alcohol.

498. *How may a magnesium compound be detected in the presence of compounds of barium and calcium?*

The barium and calcium compounds must be first separated thus: add to the solution ammonium chloride and hydrate, then ammonium carbonate; the barium and calcium compounds are precipitated and removed by filtration; to the clear filtrate add solution of sodium phosphate, if magnesium be present, a crystalline precipitate of ammonio-magnesian phosphate is formed.

499. *Under what other name is ammonio-magnesian phosphate known?*

Triple phosphate.

ZINC.

500. *For what purposes is zinc used?*

In the manufacture of brass, which is an alloy of copper and zinc, and of German silver. "Sheet zinc" is zinc rolled out into thin plates; galvanized iron is sheet iron (or iron wire, etc.), covered with a thin coating of zinc. Galvanized iron and zinc should not be used in vessels intended to contain articles of food, as fatty matter, milk, and even water become rapidly charged with soluble zinc compounds when kept in vessels made of these substances. Zinc is largely used in galvanic batteries, and in the laboratory to obtain hydrogen.

501. *How is commercial zinc nearly always contaminated?*

With arsenic, iron, and lead.

502. *How is zinc oxide obtained?*

By one of two processes: 1. By subjecting zinc carbonate to heat:

$$\underset{\text{Zinc carbonate.}}{CO_3Zn} = \underset{\text{Zinc oxide.}}{ZnO} + \underset{\text{Carbonic anhydride.}}{CO_2}$$

The zinci oxidum, U. S. P.; is thus prepared from the officinal zinc carbonate, which is a mixture of the true carbonate $ZnCO_3$, and the hydrate, ZnO_2H_2. 2. By burning metallic zinc in a current of air. This process is used on a large scale in the arts in the manufacture of "zinc white," which is used as a pigment.

503. *State the differences between samples of zinc oxide prepared by the above processes.*

That prepared by 1 is of a pale yellow color when cold, and yellow when hot, while that prepared by 2 is pure white and forms light flocculent masses, whence it was formerly known as "lana philosophica." That prepared by 1 is liable to contain an excess of carbonate.

504. *State how zinc chloride is obtained, and its properties.*

By dissolving zinc in hydrochloric acid and evaporating the solution. It is a white solid, crystallizes with difficulty, and is very soluble in water. It combines readily with albuminoid substances, and is used medicinally as an escharotic.

505. *Describe the action of zinc upon sulphuric acid.*

If both substances be pure, and the acid have the

composition SO_4H_2, there is no action; but if the acid be diluted with water the zinc is dissolved, zinc sulphate and hydrogen resulting:

$$2SO_4H_2 + Zn_2 + xH_2O = 2SO_4Zn + 2H_2 + xH_2O$$

Sulphuric acid. Zinc. Water. Zinc sulphate. Hydrogen. Water.

What part the water takes in this reaction is still unknown. Pure zinc acts much less readily on sulphuric acid than when it is contaminated with other metals. In galvanic batteries it is desirable that the action between zinc and acid should only take place while the circuit is closed; this end is attained by "amalgamating" the zincs, *i. e.*, coating them with an amalgam of zinc and mercury; plates so protected behave towards sulphuric acid like pure zinc.

506. *Why is zinc sulphate incompatible with the vegetable astringents?*

Because they contain tannic acid with which the zinc salt forms an insoluble compound.

507. *Give the analytical reactions of zinc.*

The soluble zinc compounds form, with ammonium hydrosulphide a white precipitate, insoluble in acetic but soluble in the mineral acids. With potassium ferrocyanide a white precipitate; and with ammonium hydrate a white precipitate, soluble in an excess of the reagent.

508. *What preparations of zinc are liable to give rise to cases of poisoning?*

A strong solution of the chloride with excess of acid used by tinsmiths. A disinfecting agent, known as Sir Wm. Burnett's solution, composed of 230 grains $ZnCl_2$ to the ounce of water.

509. *What should be the treatment?*

If the poison have not produced emesis it should be induced. Milk, white of egg, or better, some substance containing tannic acid, such as tea, infusion of bark, etc., should be given.

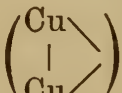
ELEMENTS OF THE COPPER GROUP

COPPER.....Cu..... 63.5
MERCURY.....Hg.....200.

510. *What is the valence of elements of this group?*
They are divalent.

511. *How many classes of salts do these elements form, and wherein do they differ?*

Two. In one class a single atom of the element acts in its divalent capacity, Cu″, thus: SO_4Cu''; in the other class two atoms of the element, linked together, form a group which behaves like a single divalent atom, thus:

 or $(Cu_2)''$; $(Cu_2)O$.

512. *Explain the nomenclature of these compounds.*

Those compounds containing the single atom are designated by the termination *ic*, while those containing the double atom $(Cu_2)''$ or $(Hg_2)''$ are designated by the termination *ous*, thus CuO is known as cupr*ic* oxide, and $(Cu_2)O$ as cupr*ous* oxide; $HgCl_2$ as mercur*ic* chloride, and $(Hg_2)Cl_2$ as mercur*ous* chloride. The termination *ous* applies to that compound containing the greater propor-

tion of metal, while the termination *ic* designates that containing the greater proportion of the other element or group of elements; thus we have:

Mercur*ous* chloride,	Hg : Cl :: 2 : 2
Mercur*ic* "	Hg : Cl :: 1 : 2
Cupr*ous* oxide,	Cu : O :: 2 : 1
Cupr*ic* "	Cu : O :: 1 : 1

COPPER.

513. *How may pure copper be obtained?*

By decomposing cupric sulphate by means of the battery (electrotype). By heating cupric oxide in a current of hydrogen:

$$\underset{\text{Cupric oxide.}}{2CuO} + \underset{\text{Hydrogen.}}{2H_2} = \underset{\text{Copper.}}{Cu_2} + \underset{\text{Water.}}{2H_2O}$$

514. *What action takes place between copper and the mineral acids?*

Copper decomposes hydrochloric acid with difficulty, except when the metal is finely divided:

$$\underset{\text{Hydrochloric acid.}}{4HCl} + \underset{\text{Copper.}}{2Cu.} = \underset{\text{Cupric chloride.}}{2CuCl_2} + \underset{\text{Hydrogen.}}{2H_2}$$

Nitric acid is energetically acted on, nitrogen dioxide being given off and cupric nitrate remaining in solution:

$$\underset{\text{Nitric acid.}}{8NO_3H} + \underset{\text{Copper.}}{3Cu} = \underset{\text{Cupric nitrate.}}{3(NO_3)_2Cu} + \underset{\text{Water.}}{4H_2O} + \underset{\text{Nitrogen dioxide.}}{2NO}$$

Warm sulphuric acid, with copper, forms cupric sulphate, while sulphur dioxide is evolved:

$$\underset{\text{Sulphuric acid.}}{2SO_4H_2} + \underset{\text{Copper.}}{Cu} = \underset{\text{Cupric sulphate.}}{SO_4Cu} + \underset{\text{Water.}}{2H_2O} + \underset{\text{Sulphur dioxide.}}{SO_2}$$

515. *What action takes place between copper and certain organic acids?*

Many weak acids are decomposed with formation of salts of copper; thus, when this metal is exposed to damp air it becomes coated with a green layer of the carbonate; acetic acid (vinegar), in contact with copper, forms the acetate; the fatty acids also combine with the metal.

516. *Give the names and formulæ of the oxides of copper.*

Cuprous oxide, Cu_2O, also known as red, or suboxide of copper; cupric oxide, CuO, also known as black, or protoxide of copper.

517. *What decomposition takes place when cupric oxide and an organic substance are heated together, and how is this utilized?*

The oxide gives up its oxygen, which, uniting with the carbon and hydrogen of the organic substance, forms carbonic anhydride and water while metallic copper remains; this reaction affords us one of the best means of analytically determining the quantity of carbon and hydrogen entering into the composition of an organic compound.

518. *What is blue vitriol?*

Cupric sulphate, SO_4Cu. Cupri sulphas, U. S. P.

519. *State its properties.*

It forms blue crystals with five molecules of water of crystallization; odorless; readily soluble in water, insoluble in alcohol; has a disagreeable, styptic taste. When heated, the water of crystallization is driven off, and a white substance remains, which absorbs water and resumes its blue color with great readiness. Its aqueous solution is acid, and coagulates albumen.

520. *How are the cupric compounds detected analytically?*

With sulphuretted hydrogen, or with ammonium hydrosulphide a black or dark brown precipitate is formed. Potash or soda produces a pale-blue precipitate, insoluble in excess of the reagent. Ammonium hydrate produces a pale blue precipitate, forming, with excess of the reagent, a dark-blue solution. Ferrocyanide of potassium produces a chestnut-brown precipitate. Metallic iron becomes coated with copper.

521. *How is copper-poisoning usually occasioned?*

By the ingestion of sulphate or acetate of copper, or, more frequently, by eating food, pickles, etc., which have been cooked or allowed to stand in copper vessels. Occasionally in workers in the metal and by the use of articles of food adulterated with copper compounds.

522. *Does copper exist normally in the body?*

It does not. In analyzing bodies, traces of this metal are sometimes found without any history of its administration; this is, however, not "physiological copper," but has found its way into the economy with the food in small quantities. Copper sulphate is frequently added to flour to render the bread white.

523. *What peculiarity is noticed in the vomit in copper-poisoning?*

It is blue or green in color. The green color due to copper may readily be distinguished from that produced by bile coloring-matter by the addition of ammonium hydrate, which produces a deep blue color if copper be present.

524. *What treatment is indicated?*

The administration of albumen (raw white of egg) with which copper salts form an insoluble compound. Emesis or stomach-pump.

525. *Give an easy clinical test for copper.*

Immerse a piece of iron (blade of a knife) into the fluid; if copper be present it will be deposited in the metallic form; the addition of a little dilute hydrochloric or sulphuric acid hastens the formation of the deposit.

MERCURY.

526. *Under what other names is this element known?*

Hydrargyrum, U. S. P.; mercurius; quicksilver.

527. *Give its symbol, valence, and atomic weight.*

Hg (Latin—Hydrargyrum). It is divalent. 200.

528. *Of how many atoms is the molecule of mercury composed?*

One.

529. *What is the principal ore of mercury?*

A native sulphide, known as cinnabar.

530. *Give the properties of elementary mercury.*

With the exception of bromine, it is the only element liquid at ordinary temperatures; when cooled to -40° it crystallizes, and when heated to 360° it boils; it is volatile at all temperatures. It has a bright metallic lustre. Pure mercury remains unchanged in air at ordinary temperatures; it unites directly with chlorine, bromine, and iodine.

531. *What is an amalgam?*

An alloy containing mercury.

532. *What important pharmaceutical preparations contain elementary mercury?*

Hydrargyrum cum cretâ=mercury with chalk; Pilulæ hydrargyri=blue-pill, blue-mass; Unguentum hydrargyri=mercurial ointment.

533. *What is the purpose of the chalk, confection and lard in these preparations?*

To keep the mercury in a state of extremely fine subdivision; globules of mercury, when pure, have a great tendency to unite with each other, this tendency is counteracted by the presence of the substances named.

534. *Has liquid mercury any action on the economy?*

It has not as long as it remains in that form.

535. *How is the mercury in the preparations named absorbed?*

In the manufacture of these preparations a notable quantity of the element is oxidized to mercurous oxide (a greater quantity in blue-pill than in mercury with chalk), this, on contact with the acids of the gastric juice or perspiration, is converted into compounds which are soluble, and therefore capable of absorption.

536. *With what substances is commercial mercury contaminated?*

Lead, tin, bismuth, zinc, and mechanical impurities.

537. *What is meant by mercur*ous *and mercur*ic *compounds?*

Like copper, mercury forms two series of compounds, in one of which the single divalent atom Hg enters; these are the mercur*ic* compounds, and contain the least proportionate amount of mer-

cury. In the other, the double atom $(Hg_2)''$ enters as a divalent group; these are the mercur*ous* compounds.

538. *What is the formula of mercurous oxide?*

Hg_2O.

539. *How is it formed, and what are its properties?*

By digesting mercurous chloride with solution of potassa. It is a black powder, odorless and tasteless; quite unstable; formerly officinal as "black precipitate."

540. *Give the chemical name and formula of the other oxide of mercury.*

Mercuric oxide, HgO.

541. *By what names is it known pharmaceutically.*

Hydrargyri oxidum rubrum, U. S. P., red precipitate, red oxide of mercury.

542. *By what two processes is it prepared?*

1. By heating mercuric nitrate as long as brown fumes are given off, and then washing with alcohol and water. 2. By adding solution of caustic soda to solution of mercuric chloride.

543. *Wherein do oxides prepared by these processes differ from each other?*

The oxide prepared by heat is crystalline, while the precipitated variety forms a yellowish red, amorphous powder. The latter is much more active in its chemical and therapeutical properties than the former.

544. *Why does the ointment of this substance deteriorate on keeping?*

Because, in contact with fats and certain other organic substances, the oxide is decomposed, the

organic matter being oxidized and metallic mercury remaining.

545. *Give the formula and synonyms of mercurous chloride.*

Hg_2Cl_2. Calomel, mild chloride of mercury, Hydrargyri chloridum mite.

546. *Give an account of its preparation.*

Mercuric sulphate is first formed by heating together mercury and sulphuric acid until a dry, white mass remains. This is then mixed with mercury and common salt, and again heated.

SO_4Hg	+	Hg	+	$2NaCl$	=	SO_4Na_2	+	Hg_2Cl_2
Mercuric sulphate.		Mercury.		Sodium chloride.		Sodic sulphate.		Mercurous chloride.

The chloride is volatilized and condensed in the upper part of the vessel, while the sodic sulphate remains. The chloride is then washed with boiling water until the washings no longer form a precipitate with ammonium hydrate.

547. *With what substance is calomel liable to be contaminated?*

With corrosive sublimate.

548. *How may this impurity be detected?*

By placing the powder upon a bright copper surface and moistening with water. If corrosive sublimate be present a silver-white stain is formed on the copper.

549. *Give the properties of mercurous chloride.*

It is a heavy, white, amorphous powder; tasteless, odorless, insoluble in water. It distils without melting. When exposed to light, it is partially decomposed into mercury and corrosive sublimate:

$$\underset{\text{Mercurous chloride.}}{Hg_2Cl_2} = \underset{\text{Mercuric chloride.}}{HgCl_2} + \underset{\text{Mercury.}}{Hg}$$

This decomposition also takes place when mercurous chloride is boiled for some time with water, and more rapidly in the cold if the water contain alkaline chlorides. It is probable that this latter decomposition occurs in the stomach when calomel is administered.

550. *Why are the mineral acids incompatible with calomel?*

Because of their tendency to decompose it, with formation of corrosive sublimate and a soluble salt of mercury with the acid. Nitro-muriatic acid produces this decomposition most readily.

551. *Why are the alkaline chlorides, bromides and iodides incompatible with calomel?*

Because in their presence there is formation of the soluble mercuric chloride, bromide or iodide. It has been found in naval practice that the use of salt provisions precludes the use of calomel.

552. *Why are the caustic and carbonated alkalies incompatible with calomel?*

Because in their presence mercurous oxide is first formed; this is rapidly decomposed into mercuric oxide and mercury, and the former, in the presence of the alkaline chlorides of the gastric juice, is converted into corrosive sublimate.

553. *Give the formula and synonyms of mercuric chloride.*

$HgCl_2$. Hydrargyri chloridum corrosivum, U. S. P., perchloride of mercury, bichloride of mercury, corrosive sublimate.

554. *Give the method of its preparation.*

By heating together mercuric sulphate and sodium chloride :

$$\underset{\text{Mercuric sulphate.}}{SO_4Hg} + \underset{\text{Sodium chloride.}}{2NaCl} = \underset{\text{Mercuric chloride.}}{HgCl_2} + \underset{\text{Sodic sulphate.}}{SO_4Na_2}$$

the chloride volatilizes, and is condensed in the upper part of the vessel—sublimes.

555. *State its properties.*

It forms heavy, white, translucent, crystalline masses, or, when pulverized, a pure white powder (calomel has a yellowish tinge), odorless. It has a strong acrid, styptic taste, and is soluble in 16 parts of cold or in 3 parts of boiling water, also soluble in alcohol and in ether. The aqueous solution is colorless, acid in reaction, and when exposed to light is decomposed, oxygen is given off, hydrochloric acid is formed, and mercurous chloride deposited :

$$\underset{\text{Mercuric chloride.}}{4HgCl_2} + \underset{\text{Water.}}{2H_2O} = \underset{\text{Mercurous chloride.}}{2Hg_2Cl_2} + \underset{\text{Hydrochloric acid.}}{4HCl} + \underset{\text{Oxygen.}}{O_2}$$

The decomposition is accelerated by the presence of organic matter.

556. *What is the action of lime-water upon the chlorides of mercury?*

With mercurous chloride mercurous oxide is formed, and is then decomposed into a mixture of mercuric oxide and mercury ; this reaction takes place in the preparation of "black wash." Yellow wash is obtained in a similar manner with mercuric chloride, and holds in suspension a yellow oxychloride.

557. *What reaction takes place between mercuric chloride and ammonium hydrate?*

A white precipitate is formed, which is regarded as ammonium chloride, NH_4Cl, in which two atoms of hydrogen are replaced by one atom of mercury, $NH_2Hg'Cl$. This is the ammoniated mercury or white precipitate of the pharmacopœia.

558. *Give the properties of the compound of mercuric chloride and albumen.*

When mercuric chloride and albumen in solution are brought together a precipitate is formed, which is insoluble in water, but is soluble in an excess of albumen, in dilute hydrochloric acid, or in solutions of alkaline chlorides.

559. *Give the antidote for corrosive sublimate poisoning.*

White of egg; the following precautions should be observed in its administration: too much should not be given at one time, lest the precipitate be dissolved in the excess; the antidote should be followed by an emetic, to remove the precipitate before it shall have been dissolved by the acid and chlorides of the gastric juice.

560. *Give the formula and synonyms of mercurous iodide.*

Hg_2I_2. Hydrargyri iodidum viride; protiodide, or green iodide of mercury.

561. *State its properties.*

It is a greenish yellow powder, odorless, tasteless, very sparingly soluble in water. It is very readily decomposed into mercuric iodide and mercury.

562. *Give the formula and synonyms of mercuric iodide*

HgI_2. Hydrargyri iodidum rubrum, red iodide, or biniodide of mercury.

563. *State its properties.*

When first formed it is yellow, but rapidly becomes scarlet. It is tasteless, odorless, permanent in air, sparingly soluble in water, but quite soluble in solutions of the chlorides, bromides, or iodides.

564. *What officinal preparation of arsenic contains mercuric iodide?*

Liquor arsenici et hydrargyri iodidi, U. S. P., commonly known as Donovan's solution

565. *What is vermilion?*

Mercuric sulphide, HgS, prepared artificially.

566. *What is the composition of turpeth mineral?*

It is a basic mercuric sulphate—*i. e.*, mercuric sulphate combined with the oxide : $SO_4Hg,2HgO$.

567. *What is the composition of Liq. hydrarg. nitratis?*

It is mercuric nitrate, $(NO_3)_2Hg$, dissolved in water containing an excess of nitric acid.

568. *Give tests for the presence of mercury.*

Sulphuretted hydrogen, passed through a solution of a mercurial compound, forms a black precipitate. A piece of bright copper in a solution containing mercury is coated with that metal; if the copper, with its adherent deposit, be washed, dried and heated in a glass tube, minute globules of mercury condense in the cold part of the tube.

569. *How may we distinguish between a mercurous and a mercuric compound?*

Hydrochloric acid produces a white precipitate with mercurous compounds, the precipitate turning black upon the addition of ammonium hydrate. Caustic potash with mercurous compounds forms a

black precipitate, and with mercuric compounds a brown or yellowish one. Potassium iodide with mercurous compounds, forms a dirty green precipitate, while with mercuric compounds a precipitate is formed, which is at first yellowish red, and afterwards scarlet, and is soluble in excess of the reagent.

570. *How may mercury be detected in saliva?*

By acidulating with hydrochloric acid and immersing a strip of bright copper. If mercury be present, a characteristic stain is formed, and on heating the copper in a glass tube, globules of mercury are condensed.

ELEMENTS OF THE IRON GROUP.

IRON.....	Fe.....	56
MANGANESE.....	Mn.....	55
CHROMIUM.....	Cr.....	52

571. *What peculiarity is there in the valence of these elements?*

They form two series of compounds, in one of which a single atom is divalent, Fe″, as in $FeCl_2$. In the other a double atom (Fe_2) behaves as a hexavalent atom, as in $(Fe_2)Cl_6$. As in the case of the mercury and copper compounds, that containing the greater relative proportion of the metal is designated by the termination *ous*, while that containing the less proportion of metal is designated by the termination *ic*, thus:

$FeCl_2$—Fe : Cl :: 1 : 2=Ferr*ous* chloride.
$(Fe_2)^{vi}Cl_6$—Fe : Cl :: 1 : 3=Ferr*ic* chloride.

572. *How do cast iron, wrought iron, and steel differ from each other in composition?*

Mainly in the different quantity of carbon contained; wrought iron is made from cast iron by burning out carbon; steel is prepared from wrought

iron by causing it again to combine with carbon. Bessemer steel is made directly from cast iron by arresting the burning out of the carbon at the proper moment. Wrought iron is used in obtaining pharmaceutical preparations.

573. *What is Ferrum redactum, U. S. P.?*

A pure and finely divided iron obtained by reducing (see Q. 42), an oxide of iron by hydrogen:

$$\underset{\text{Ferric oxide.}}{Fe_2O_3} + \underset{\text{Hydrogen.}}{3H_2} = \underset{\text{Iron.}}{Fe_2} + \underset{\text{Water.}}{3H_2O}$$

Reduced iron, or iron by hydrogen, as it is also called, should leave no residue when attracted by the magnet, such a residue is unreduced oxide.

574. *Give the formula and synonyms of ferric oxide.*

Fe_2O_3. Sesquioxide of iron, peroxide of iron, red oxide of iron, colcothar, rouge, venetian red.

575. *What is the composition of iron rust?*

Chiefly a ferric hydrate, having the composition $2Fe_2O_3,3H_2O$, with small quantities of the carbonate.

576. *What is Ferri oxidum hydratum, U. S. P., and how is it prepared?*

Ferric hydrate, $Fe_2O_3,3H_2O$, prepared by adding ammonium hydrate to solution of ferric sulphate (Liq. ferri tersulphatis, U. S. P.):

$$\underset{\text{Ferric sulphate.}}{(SO_4)_3Fe_2} + \underset{\text{Ammonium hydrate.}}{6NH_4HO} = \underset{\text{Ferric hydrate.}}{Fe_2O_3,3H_2O} + \underset{\text{Ammonic sulphate.}}{3SO_4(NH_4)_2}$$

The precipitated hydrate is collected upon a calico filter and washed.

577. *What decomposition occurs when this product is dried?*

It loses two molecules of water and is converted into the hydrate Fe_2O_3,H_2O=Ferri peroxidum hydratum, U. S. P.

578. *Give the formula, method of preparation and use of ferrous sulphide.*

FeS. It is prepared by heating together sulphur and iron filings, and is used in the laboratory to obtain sulphuretted hydrogen.

579. *Give the formula and synonyms of ferric chloride.*

Fe_2Cl_6. Ferri chloridum, U. S. P., Sesquichloride of iron, perchloride of iron.

580. *Give the U. S. P. method of its preparation.*

Iron is dissolved in hydrochloric acid when ferrous chloride, $FeCl_2$, is formed; this is then boiled with nitric acid and excess of hydrochloric acid, by which $FeCl_2$ is converted into Fe_2Cl_6. As thus prepared it always contains an excess of acid.

581. *How may neutral ferric chloride be obtained?*

By heating iron in a current of chlorine, Fe_2Cl_6 condenses in the cool part of the tube.

582. *Give the formula and synonyms of ferrous sulphate.*

SO_4Fe. Ferri sulphas, U. S. P., Sulphate of iron, green vitriol, copperas.

583. *State the method of its preparation and its properties.*

It is prepared by dissolving iron in dilute sulphuric acid and evaporating the solution to the point of crystallization. It forms apple-green crystals, containing 7Aq, odorless, having a sweetish, styptic taste, very soluble in water, insoluble in

alcohol. When exposed to the air it is decomposed.

584. *How may ferrous and ferric compounds be distinguished?*

1. Potassium ferrocyanide forms, with ferrous compounds a bluish white, and with ferric compounds a dark blue precipitate (Prussian blue). 2. Potassium ferridcyanide, with ferrous a dark blue, and with ferric, no precipitate. 3. Potassium sulphocyanate with ferrous no effect, and with ferric a deep red color.

MANGANESE.

585. *Give an account of the most important oxide of manganese.*

Manganese dioxide, MnO_2, also known as black oxide or peroxide of manganese, is the chief ore of manganese and is used in the arts in obtaining chlorine by the decomposition of hydrochloric acid:

$$MnO_2 + 4HCl = MnCl_2 + 2H_2O + Cl_2$$

Manganese dioxide. Hydrochloric acid. Manganous chloride. Water. Chlorine.

When heated to redness it gives up part of its oxygen, and has been used for obtaining that element.

586. *What chemical interest has the oxide Mn_2O_7?*

It is an anhydride whose corresponding acid, MnO_4H, has not been separated, but some of the salts of which, called permanganates, are of importance.

587. *Give the formula and properties of potassium permanganate.*

MnO_4K. It forms slender, prismatic crystals, of

a purple color with a bronze-like reflection; inodorous, and having a sweetish, astringent taste. Quite soluble in water, the solution having a deep purple color, and a pink color when extremely dilute.

588. *How does MnO_4K act as a disinfectant?*

It is a very active oxidizing agent, and its action as a disinfectant is due to the oxidation of the organic matter which it causes. It forms the basis of Condy's and several other disinfecting fluids.

NOTE.—The corresponding sodium salt is now obtained more cheaply than the potassium salt, and answers as well as a disinfectant.

589. *What objection is there to the use of MnO_4K to detect organic impurity in water?*

It is very unreliable; its decoloration is due to decomposition, it yielding up its oxygen to some oxidizable substance. Organic matter may be present in water in considerable quantity and the MnO_4K test may fail to detect it, while, on the other hand, a water containing no organic matter, but other substances capable of being oxidized by the permanganate (such as ferrous compounds or nitrites) would, according to this test, contain a large quantity of organic matter.

CHROMIUM.

590. *Give the formula of chromic anhydride.*

CrO_3. It is also known, improperly, as chromic acid—Acidum chromicum, U. S. P.

591. *How is it prepared and what are its uses?*

It is prepared by slowly adding 3 parts of sulphuric acid to 2 parts of a saturated solution of

potassium dichromate; upon cooling, a mass of dark red needles of CrO_3 separate, and are freed from excess of SO_4H_2 by draining upon a porous tile. It is one of the most active oxidizing agents we have, and, as such, is used in the laboratory and medicinally as an escharotic. In dilute solution it is used as a hardening agent in histological laboratories.

592. *Explain the chemical difference between potassium chromate and dichromate.*

The former has the formula CrO_4K_2 and the latter $Cr_2O_7K_2$; they are therefore not salts of the same acid as are carbonate and bicarbonate of potassium, CO_3Na_2 and CO_3NaH, and the name bichromate tends to mislead. The chromate is a salt of chromic acid and the dichromate a salt of dichromic acid. From the constitution of these and other salts we may consider that chromic anhydride is capable of forming three acids:

$$CrO_3 + H_2O = CrO_4H_2 \quad = \text{Chromic acid.}$$
$$2CrO_3 + H_2O = Cr_2O_7H_2 \quad = \text{Dichromic acid.}$$
$$3CrO_3 + H_2O = Cr_3O_{10}H_2 = \text{Trichromic acid.}$$

None of these acids have been separated, they are only known in their salts.

593. *State the properties of $Cr_2O_7K_2$.*

It forms prismatic crystals of a fine orange red color; odorless; having a bitter, acrid taste; soluble in water. Poisonous. When mixed with sulphuric acid it forms a powerful oxidizing agent.

594. *What is "chrome yellow?"*

Lead chromate CrO_4Pb.

595. *Give the tests for chromium.*

With lead acetate a yellow precipitate (chrome

yellow); with nitrate of silver and with mercuric chloride red precipitates. Reducing agents, as hydrogen sulphide, convert the chromates into green chromic compounds.

ALUMINIUM. Al. 27.5.

596. *What is a notable physical property of aluminium?*

Its great lightness. Of all the elements usually called metals it is the lightest with the exception of the metals of the alkalies, which latter, however, cannot be kept unaltered in air. Aluminium is also quite tough and is very useful in the manufacture of metal appliances where lightness is an object.

597. *What peculiarity is there in the valence of aluminium?*

Like iron, manganese, and chromium, aluminium forms a series of compounds in which the double atom $(Al_2)^{vi}$ behaves as a single hexavalent atom, but aluminium differs from the other elements named, in that there is no compound known in which the single divalent atom Al″ enters.

598. *How does aluminium exist in nature?*

It is one of the most abundant of the elements; its oxide, Al_2O_3, exists nearly pure as corundum, ruby and sapphire, and in a less pure form as emery. Its silicate, combined with other silicates, forms the different varieties of clay, mica, feldspar, etc.

599. *Explain the constitution of an alum.*

The sulphate of aluminium, in common with ferric, manganic, and chromic sulphates, possesses

a great tendency to combine with the sulphates of potassium, sodium and ammonium, to form definite double salts, which are called alums; thus we have:

$(SO_4)_3 Al_2, SO_4K_2$ = Aluminium potassium sulphate.
$(SO_4)_3Cr_2, SO_4K_2$ = Chromium " "
$(SO_4)_3Fe_2, SO_4Na_2$ = Iron sodium sulphate.

We may therefore express the composition of an alum, in a general way, by the formula:

$$(SO_4)_3(R_2)^{vi}, SO_4M'_2$$

in which R represents an atom of iron, chromium, manganese, or aluminium; and M an atom of an alkaline metal or a group (NH_4).

600. *To what substance is the name "alum" applied?*

Aluminium potassium sulphate, $(SO_4)_3Al_2$, $SO_4K_2 + 24Aq$; also known as potash alum—alumen U. S. P.

601. *Wherein does alumen exsiccatum U. S. P. differ from alumen?*

In having been subjected to heat, whereby the 24 molecules of water of crystallization are driven off.

602. *Into what article of food is alum fraudulently introduced, and with what effect?*

Into flour and bread; the objects being to render the bread white, and to enable the baker to use an inferior or damaged flour, as well as to adulterate the flour with a greater quantity of rice, potatoes, etc., without probability of detection. Of course the prolonged use of such bread produces disorders of digestion.

GOLD. Au. 197.

603. *What are the symbol and valence of gold?*

Au, from the Latin Aurum. Gold forms two series of compounds, in one of which it is univalent, as in aurous chloride, AuCl, and in the other trivalent, as in auric chloride, $AuCl_3$.

604. *By what agents is gold attacked?*

By free chlorine or bromine, by nitro-muriatic acid, from which chlorine is liberated. Mercury dissolves gold, forming a liquid amalgam. It is not attacked by any single acid or by any alkali.

605. *What is the composition of United States gold coin?*

900 parts of gold, alloyed with 100 of copper. Jeweler's gold (18 carat) contains about $\frac{750}{1000}$ gold, the remainder being copper and silver in proportions varying with the color.

606. *What compound of gold is used in the chemical and histological laboratories?*

Auric chloride, $AuCl_3$ = terchloride of gold.

PLATINUM. Pt. 198.

607. *To what uses is metallic platinum put?*

In making vessels which are not attacked by any single acid and bear a high heat without fusion. Large retorts made of this metal are used in the concentration of sulphuric acid.

608. *What precautions are to be had in using platinum vessels?*

Although not attacked by single acids, platinum vessels are injured by many substances. The metal is attacked by nitromuriatic acid, or any

substance liberating chlorine. Platinum has a great tendency to alloy with other metals; therefore, no metal or easily reducible oxide should be heated in contact with it. The alkalies and alkaline carbonates and, under certain conditions, the alkaline phosphates attack platinum; when these substances are to be heated, silver vessels should be used, care being taken, however, that the heat be not pushed beyond the fusing point of that metal. Platinum vessels should never be heated over an alcohol or coal fire, because when so heated the metal becomes blackened and brittle.

609. *What is the valence of platinum?*

It forms two series of compounds, in one of which it is bivalent, as in $Pt''Cl_2$ = platinous chloride; and in the other quadrivalent, as in $Pt^{iv}Cl_4$ = platinic chloride.

610. *For what purpose is platinic chloride used in chemistry?*

As a test for the presence of the compounds of potassium and ammonium, with which it forms insoluble, yellow, crystalline compounds.

COMPOUNDS OF CARBON.

611. *Under what other name are these compounds known?*

Organic substances.

612. *What is the distinction between organic and inorganic substances?*

Any compound containing carbon is an organic compound, whether it be a constituent of a vegetable or animal body, or not. The division is simply one of convenience, and is retained owing to the great number of the carbon compounds.

613. *What are the valence, symbol, and atomic weight of carbon?*

It is tetravalent, its symbol is C, and its atomic weight 12.

614. *Of what four elements are organic compounds principally composed?*

Carbon. hydrogen, oxygen, and nitrogen.

615. *What elements may enter into the composition of organic compounds?*

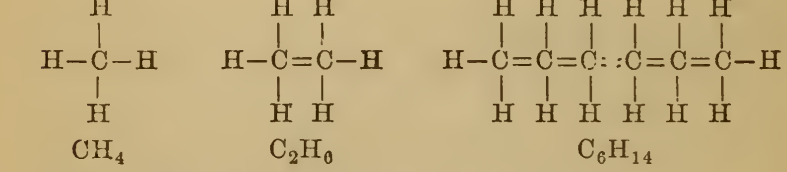
All the elements.

616. *What is a saturated compound?*

One in which all the valences of the constituent elements are satisfied, as in $C^{iv}H'_4$.

617. *What property do the atoms of carbon possess to an extraordinary degree, and what bearing has this upon organic chemistry?*

The power of combining with each other and interchanging valences, which thus equalize each other and disappear; were it not for this property of carbon the number of its compounds would be very much smaller than it is; we could, for example, have but one saturated compound of carbon with hydrogen; $C^{iv}H_4$; we have, however, a large number of such compounds, the constitution of some of which may be thus represented:



CH_4 C_2H_6 C_6H_{14}

618. *What is understood by substitution?*

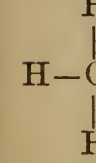
The replacement of an atom or atoms of one element for an equivalent number of atoms of another element in a compound. Example.—The compound CH_4 being saturated, it is impossible to introduce any other atom into its molecule without, at the same time, displacing therefrom one or more of its atoms; by acting upon CH_4 with chlorine, it is possible to remove each of the atoms of hydrogen and *substitute* therefor atoms of chlorine, forming the substituted compounds CH_3Cl; CH_2Cl_2; $CHCl_3$; CCl_4.

619. *What is a radical?*

A group of atoms, which is not necessarily capable of isolation, the members of which are so strongly linked together that it is capable of passing un-

altered from one compound to another, and in this behaving like an atom.

Example.—Let us consider the compound CH_4 as composed of CH_3H; if we act upon this with iodine we obtain a compound CH_3I; if we now treat this substance, under proper conditions, with potash, we obtain a compound CH_3OH; and, if we act upon this with acetic acid we obtain a compound $CH_3C_2H_3O_2$; this group CH_3 is, therefore, capable of passing from one combination to another without undergoing change itself, it is a radical; as it is composed of one atom of the quadrivalent carbon, three of whose valences are satisfied with atoms of hydrogen, there remains one free valence,



H—C—, and the radical behaves like an atom of an univalent element $(CH_3)'$. This idea of radicals is a very important one to the proper understanding of organic chemistry.

620. *What are meant by types?*

Common substances; the arrangement of the atoms in whose molecules may be taken as representative of whole classes of other substances, whose molecules have a similar arrangement.

621. *Under what three types may all organic substances be classified?*

Hydrogen, water, and ammonia. The molecule of hydrogen consists of two atoms united together, thus: $\left.\begin{matrix} H \\ H \end{matrix}\right\}$; the molecule of water is composed of

two atoms of hydrogen (univalent) united to one atom of oxygen (divalent), thus: $O\begin{cases}H\\H'\end{cases}$, or $\left.\begin{matrix}H\\H\end{matrix}\right\}O$; the molecule of ammonia consists of three atoms of hydrogen united to one atom of nitrogen (trivalent); under these three types (either singly or combined with each other) all organic substances, whose constitution is known, can be arranged, and we may consider all chemical substances as either hydrogen, water, or ammonia (or a union of two of them) in which one or more of the atoms have been replaced by another atom or a radical, thus:

Hydrogen Type.	Water Type.	Ammonia Type.
$\left.\begin{matrix}H\\H\end{matrix}\right\}$	$\left.\begin{matrix}H\\H\end{matrix}\right\}O''$	$\left.\begin{matrix}H\\H\\H\end{matrix}\right\}N.'''$
$\left.\begin{matrix}(CH_3)'\\H\end{matrix}\right\}$	$\left.\begin{matrix}(CH_3)'\\H\end{matrix}\right\}O''$	$\left.\begin{matrix}(CH_3)'\\H'\\H'\end{matrix}\right\}N'''$
Marsh gas.	Wood spirit.	Methylamine.

622. *What are* isomeric *bodies?*

Substances which, upon analysis, prove to have the same centesimal composition, but which differ in their properties.

623. *How many kinds of isomerism are recognized, and how are they designated?*

Two. Metamerism and Polymerism.

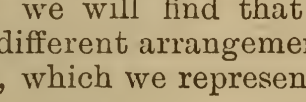
624. *When are two substances said to be metameric?*

When their molecules contain equal numbers of atoms of the same elements. Example: If we analyze two substances known as methyl formiate

and acetic acid, we will obtain exactly the same centesimal result for each, thus:

Carbon	40.
Hydrogen	6.67
Oxygen	53.33
	100.—

And if we examine these bodies further we will find that they each contain the same number of atoms of C, H and O, viz., C, 2 atoms; H, 4 atoms; O, 2 atoms; they would both then have the formula $C_2H_4O_2$; yet they differ from each other very materially in their properties, and if we examine them more closely, we will find that these differences are due to a different arrangement of the atoms in the molecule, which we represent thus:



Methyl formiate. Acetic acid.

These bodies are metameric.

625. *When are substances said to be* polymeric?

When, although they have the same centesimal composition, the molecule of one contains some multiple of the number of each of the atoms contained in the molecule of the other. Example: If we make an analysis of grape sugar, we will obtain exactly the same centesimal result as we obtained for acetic acid and methyl formiate; but if we examine the chemistry of grape sugar carefully, we find that its molecule is not made up of $C_2H_4O_2$, but of three times the number of each of the atoms, or $C_6H_{12}O_6$; these substances are polymeric.

SATURATED HYDROCARBONS, C_nH_{2n+2}

CH_3 / H	Methyl hydride.	C_9H_{19} / H	Nonyl hydride.
C_2H_5 / H	Ethyl "	$C_{10}H_{21}$ / H	Decyl "
C_3H_7 / H	Propyl "	$C_{11}H_{23}$ / H	Undecyl "
C_4H_9 / H	Butyl "	$C_{12}H_{25}$ / H	Bidecyl "
C_5H_{11} / H	Amyl "	$C_{13}H_{27}$ / H	Tridecyl "
C_6H_{13} / H	Hexyl "	$C_{14}H_{29}$ / H	Tetradecyl "
C_7H_{15} / H	Heptyl "	$C_{15}H_{31}$ / H	Pentadecyl "
C_8H_{17} / H	Octyl "	$C_{16}H_{33}$ / H	Hexadecyl "

626. *What is a hydrocarbon?*

A compound containing only carbon and hydrogen.

627. *What is an homologous series?*

A series of compounds, each term of which differs from the next by CH_2 more or less. By examining the above list it will be found that by adding CH_2 to the formula of the first the formula of the second will be obtained, and so on.

628. *What is a general formula?*

An algebraic formula applicable to an entire homologous series. Thus the general formula of the series under consideration is C_nH_{2n+2}, and from this formula that of any member of the group may be deduced, if its position in the series

be known. If, for example, the formula of the 5th in the series be required n=5, and we have $C_5H_{(5\times 2)+2}$ or C_5H_{12}. The general formula may be stated either as above or in such a manner as to indicate the constitution of the body thus, $\left.\begin{matrix} C_nH_{2n+1} \\ H \end{matrix}\right\}$

629. *What is understood by the "constitution" of a substance?*

The arrangement of the atoms within the molecule.

630. *What natural product is composed mainly of saturated hydrocarbons?*

Petroleum. [The terms of this series vary regularly as to their boiling-point, from the lowest, which is gaseous at ordinary temperatures, to the 16th, which only boils at about 280°C. A petroleum is liable to explode in proportion as it contains hydrocarbons of low boiling-point.]

METHYL COMPOUNDS.

631. *What is the composition of the radical methyl?*

CH_3.

632. *Give the formula and synonyms of methyl hydride.*

$\left.\begin{matrix} CH_3 \\ H \end{matrix}\right\}$. It is also known as Marsh gas, fire damp, light carburetted hydrogen.

633. *Describe its properties.*

It is a colorless, odorless, tasteless gas, lighter than air, sparingly soluble in water; burns with a yellow flame; forms explosive mixtures with air and oxygen; a large quantity of carbon dioxide is

formed in an explosion of such a mixture, and is known to miners as "after damp."

634. *What important substance results from the substitution of three atoms of chlorine for atoms of hydrogen in methyl hydride?*

Chloroform, which is chloride of bichlorinated methyl, $\left.\begin{matrix} CHCl_2 \\ Cl \end{matrix}\right\}$.

635. *State its physical properties.*

It is a colorless, volatile liquid, having an agreeable ethereal odor and a sweet taste. It is heavier than water, with which it does not mix; it mixes in all proportions with alcohol and ether. It boils at 60° C. It can only be ignited with difficulty. It is a good solvent for fats and all substances rich in carbon, gutta-percha.

636. *How is chloroform tested for impurities?*

When used for inhalation it should respond to the following tests: Its sp. gr. should be 1.49. When shaken with an equal volume of colorless sulphuric acid the mixture should not become hot, and after twenty-four hours the upper (chloroform) layer should be absolutely colorless, while the acid layer should have only a pale yellow tinge. When thrown upon water it should sink in transparent drops, and the water should not become milky. When evaporated the last portions should leave no pungent odor, and the remaining film of moisture should be tasteless and odorless.

637. *How may $CHCl_3$ be detected?*

By passing the vapor, obtained by heating the suspected substance to 100°, through a tube heated to redness, the other end of which is bent down and dips into a solution of nitrate of silver. If

chloroform be present it is decomposed, and the liberated chlorine produces a white precipitate of silver chloride.

638. *How are bromoform and iodoform related to chloroform?*

They have the same constitution, bromine or iodine replacing the chlorine :

$CHCl_2$)	$CHBr_2$)	CHI_2)
Cl (	Br (	I (
Chloroform.	Bromoform.	Iodoform.

639. *State the principal properties of iodoform.*

It forms yellow crystals, having a strong, disagreeable odor. Insoluble in water, soluble in alcohol. It contains 96 per cent. of its weight of iodine.

640. *Upon what type are the foregoing methyl compounds constituted?*

The hydrogen type $\left.\begin{matrix} H \\ H \end{matrix}\right\}$.

641. *Give the formula, constitution, and synonyms of methyl hydrate.*

$\left.\begin{matrix} CH_3 \\ H \end{matrix}\right\}$ O. Methyl alcohol; wood spirit; pyroxylic spirit; wood naphtha.

642. *Of what important homologous series is this the first term?*

The monotomic alcohols $C_nH_{2n} + {}_2O$.

643. *How is methyl alcohol obtained commercially?*

By the distillation of wood.

644. *What is methylated spirit?*

Spirits of wine containing ten per cent. of wood spirit. This does not interfere with its use in the arts, but communicates a disagreeable taste and odor which prevent its being taken internally.

ETHYL COMPOUNDS.

645. *What is the composition of the radical ethyl?*

$(C_2H_5)'$.

646. *Give the formula and synonyms of ethyl chloride.*

$\left.\begin{matrix}C_2H_5\\Cl\end{matrix}\right\}$. Hydrochloric ether; muriatic ether.

647. *Give the formula and synonyms of ethyl hydrate.*

$\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}O$. Alcohol; ethylic alcohol.

648. *What is an alcohol?*

An organic compound containing no nitrogen and capable of reacting directly with an acid to form water and a neutral body known as an ether. The alcohols thus resemble the metallic hydrates, and the ethers have the constitution of salts.

$$\underset{\text{Alcohol.}}{\left.\begin{matrix}(C_2H_5)\\H\end{matrix}\right\}O} + \underset{\text{Acetic acid.}}{\left.\begin{matrix}(C_2H_3O)\\H\end{matrix}\right\}O} = \underset{\text{Water.}}{\left.\begin{matrix}H\\H\end{matrix}\right\}O} + \underset{\text{Acetic ether or ethyl acetate.}}{\left.\begin{matrix}(C_2H_3O)\\C_2H_5\end{matrix}\right\}O}$$

$$\underset{\text{Potassium hydrate.}}{\left.\begin{matrix}K\\H\end{matrix}\right\}O} + \underset{\text{Acetic acid.}}{\left.\begin{matrix}(C_2H_3O)\\H\end{matrix}\right\}O} = \underset{\text{Water.}}{\left.\begin{matrix}H\\H\end{matrix}\right\}O} + \underset{\text{Potassium acetate.}}{\left.\begin{matrix}(C_2H_3O)\\K\end{matrix}\right\}O}$$

649. *Explain the method of obtaining alcohol.*

The source of all the alcohol obtained in the arts is grape sugar or some substance, such as starch, which is easily converted into grape sugar. This substance, in the presence of certain low forms of vegetable life, under proper conditions of tempera-

ture, undergoes what is known as *fermentation*, a process which consists mainly in the splitting up of the sugar into alcohol and carbon dioxide :

$$\underset{\text{Grape sugar.}}{C_6H_{12}O_6} = \underset{\text{Alcohol.}}{2C_2H_6O} + \underset{\text{Carbon dioxide.}}{2CO_2}$$

The alcohol is afterwards separated, in a condition of greater or less purity, from other substances by distillation.

650. *Explain the difference between the various kinds of ethyl alcohol used in the arts and in pharmacy.*

They differ from each other only in the proportion of alcohol and water.

Absolute alcohol—is pure alcohol, C_2H_6O. [It is only obtained with difficulty, and deteriorates rapidly, owing to its great tendency to absorb water. The so-called absolute alcohol of the shops is seldom stronger than 98 per cent.]

Alcohol fortius, U. S. P. — Stronger alcohol. Has a specific gravity of 0.817, and contains 92 per cent. alcohol. [Manufacturing apparatus has been so perfected that alcohol of this strength may be obtained by a single distillation.]

Alcohol, U. S. P.—Rectified spirit—contains 85 per cent. alcohol. [This is the alcohol generally used in the arts.]

Proof spirit—Spirits of wine—contains 49 per cent. alcohol.

651. *State the principal properties of alcohol.*

It is a colorless, mobile fluid, having, when pure, sp. gr. 0.794, and boiling point, 78°. It has a peculiar odor and a sharp, burning taste ; very volatile ; it has not been solidified, but at -110^c

becomes sirupy. It has a great attraction for water, and to this are due its coagulating action on albumen and its preservative action on animal substances. It is a very useful solvent.

652. *What is the alcoholic strength of "spirituous liquors"?*

From 53 to 56 per cent. alcohol.

653. *To what is the color of brandy, whiskey, etc., due?*

To coloring-matter from the wood of the cask, or to burnt sugar intentionally added.

654. *Mention the sources of some of the principal spirits.*

Brandy (spir. vini Gallici, U. S. P.) is obtained by subjecting wine to distillation. Rum, by fermenting and distilling molasses. American whiskey, from rye or Indian corn; the starch of the grain is first converted into glucose; this is fermented and distilled. Irish whiskey, from potatoes; and Scotch whiskey, from barley, in the same way. [The peculiar smoky flavor is produced by drying the grain over a peat fire.] Gin is obtained from various grains, and is flavored with juniper berries.

655. *Wherein do wines differ from spirits?*

In that they contain a smaller proportion of alcohol, and, as they are not subjected to distillation, in containing a variety of solid substances present in the juice of the grape, which do not exist in spirits.

656. *What is the alcoholic strength of "light" wines?*

From 7 to 10 per cent.

657. *Of heavy wines?*

From 14 to 17 per cent.

658. *What heavy wines are officinal?*

Sherry and port (Vinum Xericum and Vinum Portense). [The latter should be removed from the Pharmacopœia, as it is obtained pure in this country with great difficulty.]

659. *What is the alcoholic strength of malt liquors?*

From $1\frac{1}{2}$ to 9 per cent.

660. *What substance is formed by substituting for the remaining extraradical hydrogen of alcohol the radical ethyl?*

Oxide of ethyl, or ethylic ether, $\left.\begin{matrix}(C_2H_5)'\\(C_2H_5)'\end{matrix}\right\}O =$ $C_4H_{10}O$, commonly known as "sulphuric ether."

661. *Why is the name "sulphuric ether" improper as applied to this substance?*

Because it contains no sulphur; the name properly applies to another substance, $\left[\left.\begin{matrix}SO_2\\(C_2H_5)_2\end{matrix}\right\}O^2\right]$. It should be called ethylic ether.

662. *Describe the manufacture of ether.*

A mixture of sulphuric acid and alcohol is maintained at a temperature of 140–145° in a retort into which flows a slow but constant stream of alcohol, and which is connected with a suitable condenser. The first distillation yields a mixture of ether, alcohol, and small quantities of sulphuric acid. To purify the ether, this mixture is shaken with milk of lime and water; upon standing, the ether, purified from sulphuric acid and alcohol, rises to the surface, and is decanted. This product is known as "washed ether," and still contains water, which can only be removed by the addition of calcium chloride and redistillation; as thus purified, it forms the Æther fortior, U. S. P.

663. *Explain the conversion of alcohol into ether.*

A small quantity of sulphuric acid is capable of etherifying a large quantity of alcohol; this was therefore one of the processes formerly explained by the empty word "catalysis," until Williamson showed the true method of its action. One molecule of sulphuric acid and one of alcohol first act upon each other, the ethyl of the alcohol replacing an atom of hydrogen of the acid with formation of a substance called sulphovinic acid:

$$\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}O + \left.\begin{matrix}SO_2\\H_2\end{matrix}\right\}O_2 = \left.\begin{matrix}SO_2\\H\\(C_2H_5)\end{matrix}\right\}O_2 + \left.\begin{matrix}H\\H\end{matrix}\right\}O$$

Alcohol. Sulphuric acid. Sulphovinic acid. Water.

As soon as the sulphovinic acid is formed it reacts molecule for molecule with alcohol, giving up again the radical ethyl which replaces the extraradical hydrogen of the alcohol, while sulphuric acid is regenerated:

$$\left.\begin{matrix}SO_2\\H\\(C_2H_5)\end{matrix}\right\}O_2 + \left.\begin{matrix}(C_2H_5)\\H\end{matrix}\right\}O = \left.\begin{matrix}(SO_2)\\H_2\end{matrix}\right\}O_2 + \left.\begin{matrix}(C_2H_5)'\\(C_2H_5)'\end{matrix}\right\}O$$

Sulphovinic acid. Alcohol. Sulphuric acid. Ether.

664. *State the properties of ethylic ether.*

It is a colorless, mobile liquid, having a peculiar and tenacious odor; it is lighter than water, in which it is only slightly soluble. It boils at 35° at ordinary barometric pressure, and is very volatile at all temperatures. It is highly inflammable, and its vapor forms an explosive mixture with air.

665. *What precautions are to be observed to guard against ignition of ether?*

That it be used at a distance from lights and fires. The vapor of ether is heavier than air, and more danger is therefore to be apprehended from a grate fire than from a chandelier; of course, in administering ether at night the light should be held well above the patient.

666. *What is a compound ether?*

A substance resembling a salt, the difference being that the hydrogen of the acid is replaced by an organic radical in place of by a metal. The alcohols behave towards the acids in a manner precisely like the metallic hydrates:

$$\left.\begin{matrix}NO_2\\H\end{matrix}\right\}O + \left.\begin{matrix}K\\H\end{matrix}\right\}O = \left.\begin{matrix}NO_2\\K\end{matrix}\right\}O + \left.\begin{matrix}H\\H\end{matrix}\right\}O$$

Nitric acid. Potassium hydrate. Potassium nitrate. Water.

$$\left.\begin{matrix}NO_2\\H\end{matrix}\right\}O + \left.\begin{matrix}(C_2H_5)\\H\end{matrix}\right\}O = \left.\begin{matrix}NO_2\\C_2H_5\end{matrix}\right\}O + \left.\begin{matrix}H\\H\end{matrix}\right\}O$$

Nitric acid. Alcohol. Ethyl nitrate or nitric ether. Water.

667. *What is the formula of nitrous ether, and in what officinal preparation does it exist?*

$\left.\begin{matrix}NO\\(C_2H_5)\end{matrix}\right\}O$. Spiritus ætheris nitrosi, U. S. P.; sweet spirits of nitre is a solution of this substance in alcohol.

668. *What is the composition of the true sulphuric ether?*

$\left.\begin{matrix}SO_2\\(C_2H_5)_2\end{matrix}\right\}O_2$ = ethyl sulphate.

669. *Give the formula and synonyms of amyl hydrate.*

$\left.\begin{matrix}C_5H_{11}\\H\end{matrix}\right\}O$. Amyl alcohol, fusel oil, grain oil, potato spirit.

670. *What practical interest attaches to it?*

It is produced in small quantities with ethylic alcohol in fermentation, and, as it has deleterious properties, must be carefully separated from the spirits.

MONOBASIC ACIDS. $C_nH_{2n}O_2$ $\left.\begin{matrix} C_nH_{2n-1}O \\ H \end{matrix}\right\} O.$

671. *Explain the formation of these acids.*

They are formed by the oxidation of the series of alcohols just considered, and result from the substitution of one atom of oxygen for two atoms of hydrogen in the radical:

$$\left.\begin{matrix} C_2H_5 \\ H \end{matrix}\right\} O \qquad \left.\begin{matrix} (C_2H_3O)' \\ H \end{matrix}\right\} O$$

Alcohol. Acetic acid.

The oxygenated radical, so formed, exists in compounds having the same constitution as the compounds of the alcoholic radicals, thus we have hydrides, hydrates, oxides, etc.

$$\left.\begin{matrix} (C_2H_3O) \\ H \end{matrix}\right\} \quad \left.\begin{matrix} (C_2H_3O) \\ H \end{matrix}\right\} O \quad \left.\begin{matrix} (C_2H_3O) \\ (C_2H_3O) \end{matrix}\right\} O$$

Acetyl hydride. Aldehyde. Acetyl hydrate. Acetic acid. Acetyl oxide. Acetic anhydride.

672. *What is the constitution of chloral?*

It is acetyl hydride, or aldehyde, in which the three atoms of hydrogen of the radical have been replaced by chlorine:

$$\left.\begin{matrix} (C_2H_3O)' \\ H \end{matrix}\right\} \qquad \left.\begin{matrix} (C_2Cl_3O)' \\ H \end{matrix}\right\}$$

Acetyl hydride. Aldehyde. Trichloracetyl hydride. Chloral.

673. *State the properties of chloral.*

It is an oily, colorless liquid, having a penetrat-

ing odor, and giving off irritating vapors; it is quite unstable. When mixed with water combination occurs, and chloral hydrate, C_2Cl_3HO,H_2O, is formed as a white crystalline solid.

674. *What reaction takes place between chloral or its hydrate and the alkalies?*

When the two are brought together the mixture becomes milky, and after a time separates into two layers, the lower of chloroform, and the upper a solution of potassium formiate:

$$\underset{\text{Chloral.}}{C_2HCl_3O} + \underset{\substack{\text{Potassium}\\\text{hydrate.}}}{KHO} = \underset{\text{Chloroform.}}{CHCl_3} + \underset{\substack{\text{Potassium}\\\text{formiate.}}}{CHO_2K}$$

It is to the occurrence of this decomposition in the blood that chloral owes its therapeutic value.

675. *What acid of this series is obtained from ethylic alcohol?*

Acetic acid = Acetyl hydrate $\left.\begin{matrix}C_2H_3O\\H\end{matrix}\right\}O$.

676. *How is the pure acid designated, and what are its properties?*

Glacial acetic acid; Acidum aceticum glaciale, U. S. P. A colorless liquid, which solidifies to an ice-like mass at 17° and boils at 119°. It has a pungent odor and a pure acid taste and acid reaction. It attracts moisture from the air, and should be kept in well-closed bottles. The commercial acid usually contains about 35 per cent. $C_2H_4O_2$.

677. *What is the composition of vinegar, and how is it obtained?*

It is dilute acetic acid, holding in solution certain volatile and extractive matters. It is prepared

by the oxidation of some substance containing alcohol, as wine, cider, infusion of malt.

678. *Describe the various products of the oxidation of alcohol.*

These vary according as the oxidizing agent be energetic, as chromic anhydride, the alcohol burns, and is converted into carbon dioxide and water:

$$\underset{\text{Alcohol.}}{C_2H_6O} + \underset{\text{Oxygen.}}{3O_2} = \underset{\text{Carbon dioxide.}}{2CO_2} + \underset{\text{Water.}}{3H_2O}$$

If the oxidation take place more slowly it is limited to the substitution of an atom of oxygen for two of hydrogen in the radical, forming acetic acid:

$$\underset{\text{Alcohol.}}{C_2H_6O} + \underset{\text{Oxygen.}}{O_2} = \underset{\text{Acetic acid.}}{C_2H_4O_2} + \underset{\text{Water.}}{H_2O}$$

If the action take place still more slowly aldehyde is formed:

$$\underset{\text{Alcohol.}}{2C_2H_6O} + \underset{\text{Oxygen.}}{O_2} = \underset{\text{Aldehyde.}}{2C_2H_4O} + \underset{\text{Water.}}{2H_2O}$$

679. *How is vinegar adulterated?*

With sulphuric acid, water, capsicum, corrosive sublimate. It is also frequently contaminated with lead.

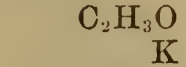
680. *What are the aceta or vinegars of the U. S. P.?*

Solutions of active substances in dilute acetic acid; not in vinegar.

681. *What are the salts and ethers of acetic acid called, and what is their constitution?*

Acetates. Acetic acid contains in each molecule one atom of hydrogen capable of being replaced by

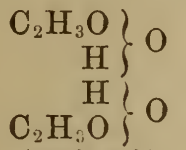
a metal; the acetates of the univalent metals and radicals, therefore, have the constitution:



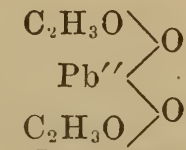
Potassium acetate.

Ethyl acetate.

while those of the divalent metals are formed by one atom of the metal replacing the hydrogen of two molecules of acid:



Acetic acid, 2 molecules.



Lead acetate.

682. *How is sodium acetate prepared?*

By adding acetic acid to solution of sodic carbonate until effervescence ceases:

$$CO_3Na_2 + 2C_2H_3O_2H = 2C_2H_3O_2Na + H_2O + CO_2$$

Sodium carbonate. Acetic acid. Sodium acetate. Water. Carbon dioxide.

683. *In what pharmaceutical preparation does ammonium acetate exist?*

Liquor ammoniæ acetatis, U. S. P., = Spiritus Mindereri.

684. *What is verdigris?*

A mixture, in varying proportion, of the basic acetates of copper.

685. *What is meant by a* basic *or* sub *salt?*

A compound of the salt with the oxide of the metal, thus one of the basic copper acetates has the composition $(C_2H_3O_2)_2Cu$, CuO; when these exist the regularly formed compound is sometimes designated as the *normal* salt $(C_2H_3O_2)_2Cu$.

686. *How does verdigris frequently give rise to poisoning?*

When food containing vinegar is cooked or allowed to stand in copper vessels. The reprehensible practice of "greening" pickles by boiling the vinegar in copper, or by adding to it copper coins, has produced serious results.

687. *Give the formula and synonyms of lead acetate.*

$(C_2H_3O_2)_2Pb''$. Sugar of lead, salt of Saturn.

688. *State its important properties.*

It forms large, transparent crystals, soluble in water, having a sweet, astringent taste, leaving a metallic after-taste. It is poisonous. It is a valuable agent in animal chemistry, as it forms insoluble compounds with a number of organic substances which may thus be separated.

689. *Of what pharmaceutical products is a basic lead acetate the active ingredient?*

Goulard's extract=Liq. plumbi subacetatis, U. S. P., and Goulard's cerate=Ceratum plumbi subacetatis, U. S. P.

690. *What is the composition of acetic ether?*

It is ethyl acetate $\left.\begin{matrix} C_2H_3O \\ (C_2H_5) \end{matrix}\right\}$ O.

691. *Of what class of substances do the artificial fruit essences mainly consist?*

Of the compound ethers of the acids of this class with the univalent alcoholic radicals. They are constituted in a manner similar to acetic ether.

692. *Give the formula, occurrence, and method of artificial preparation of valerianic acid.*

$\left.\begin{matrix} C_5H_9O \\ H \end{matrix}\right\}$ O. It occurs in valerian root, but is

more easily obtained by the oxidation of amylic alcohol:

$$\left.\begin{matrix} C_5H_{11} \\ H \end{matrix}\right\} O + O_2 = \left.\begin{matrix} C_2H_9O \\ H \end{matrix}\right\} O + H_2O$$

Amyl hydrate. Oxygen. Valerianic acid. Water.

693. *What valerianates are officinal?*

Those of sodium, ammonium, zinc, and quinia.

694. *Describe the process for obtaining zinc valerianate.*

A mixture of valerianic acid and amyl valerianate is first obtained by oxidizing amylic alcohol with sulphuric acid and potassium dichromate; to this, solution of soda is added to neutralization, after which the fluid, on evaporation, yields solid sodium valerianate. To obtain the zinc salt, hot solutions of sodium valerianate and zinc sulphate are mixed; when sodium sulphate and zinc valerianate are formed, a part of the latter crystallizes out on cooling, and a further quantity is obtained by partially evaporating the mother liquor.

695. *In what parts of the economy does butyric acid occur?*

In the perspiration, muscular tissue, and in the contents of the intestines and fecal matter.

696. *Explain the formation of free butyric acid in the intestine.*

It is partially formed by the decomposition of butyrates contained in certain fats, but the greater quantity has its source from the saccharine elements of food, which are, to a certain extent, first converted into lactic acid, and this into butyric acid.

NOTE.—There exist a number of compounds derived from this series of acids by the substitution of a group $(NH_2)'$ for

an atom of hydrogen in the radical. These are known as "amido-acids" (*e. g.*, $C_2H_2(NH_2)\begin{matrix}O\\H\end{matrix}\}$ O=amidoacetic acid), and some of them are important constituents of animal bodies.

697. *Under what other names is amidoacetic acid known?*

Glycin, glycocol, glycocine.

698. *How does it occur in the body?*

It is not found in the economy as such, but enters into the composition of a peculiar acid, which is found as its sodium salt in the bile, and is known as glycocholic acid.

699. *What other peculiar acid is found in human bile?*

Taurocholic acid; also in the form of its sodium salt.

700. *How may sodium taurocholate and glycocholate be separated from the bile and from each other?*

The method for their separation from the other constituents of the bile is based upon their solubility in alcohol and in water, and their insolubility in ether. The bile is evaporated at 100° to dryness, and the residue extracted with absolute alcohol. This extract is filtered through animal charcoal, and shaken with ten times its volume of ether. After a varying period, the salts separate in the form of bundles of acicular needles or oily drops, the taurocholate crystallizing more difficultly than the glycocholate. To separate the two acids, advantage is taken of the different action of the lead acetates upon them. The neutral acetate forms insoluble precipitates with both acids, while the subacetate only precipitates with taurocholic acid.

701. *State what is known of the physiology of these salts.*

They do not exist in the blood, but are formed in the liver (when injected into the circulation they are poisonous, the symptoms being similar to those observed in icterus from obstruction). In the intestine they are decomposed, and the substances resulting from their decomposition are partly, if not entirely, reabsorbed.

702. *Describe Pettenkofer's reaction for bile.*

The fluid (urine, etc.) is evaporated to dryness at 100°; the residue is extracted with strong alcohol, and the extract mixed with ten volumes of ether. The precipitate formed is collected upon a filter, and, after having been washed with ether, is dissolved in a small quantity of water. To this aqueous solution a drop or two of a solution of cane sugar (strength—one sugar to four water) and then strong sulphuric acid are added. The addition of the acid must be so conducted that the temperature of the mixture does not rise above 70°. If the bile salts be present, a turbidity usually appears at first, and then a fine purple color, more or less intense according to the quantity of biliary salt present.

703. *To what substance is this reaction due?*

Cholic acid, formed by the decomposition of the tauro or glycocholate.

704. *Why can the method given in* 702 *not be simplified?*

Because the same reaction occurs with numerous other substances—as albumen, fibrin, oleic acid and the oleates, amylic alcohol, the salts of morphine and codeine, etc. The object of the

first part of the process, as given in 702, is to separate any of these substances that may be present.

705. *Under what name is amidocaproic acid generally known, and what is its constitution?*

Leucin. $C_6H_{10}(NH_2)O \left\{ \begin{matrix} \\ H \end{matrix} \right\} O$

706. *Where does it occur, and how is it formed?*

It is formed in most animal tissues in small quantities, notably in the pancreas. It has not been detected in the blood or urine in health, but appears in the latter fluid in yellow atrophy of the liver. It results from the decomposition of albuminoid substances out of the body by the action of strong alkalies or acids, and during putrefaction. In the body it is formed during the processes of nutrition, and is subjected to further change. It is not eliminated in health.

ACRYLIC SERIES OF ACIDS.

707. *How do acids of this series differ from those of the acetic series in composition?*

They contain two atoms of hydrogen less, their general formula being $C_nH_{2n-2}O_2$.

708. *What two acids of this series are of medical interest?*

Crotonic acid, $C_4H_6O_2$, and oleic acid, $C_{18}H_{34}O_2$.

709. *Mention the points of interest of crotonic acid.*

It exists in combination with glycerin as an ether in croton oil. The aldehyde corresponding to this acid, C_4H_6O, furnishes a chlorinated derivative similar to chloral, a hydrate of which is used medicinally under the name croton chloral hydrate.

710. *In what form does oleic acid exist in nature?*

In combination with glycerine it forms the greater part of all the oils, animal and vegetable.

711. *What are its properties?*

A colorless or slightly yellow, oily fluid, neutral in reaction when pure; upon exposure to air it becomes yellow, rancid, and acid. At 4° it solidifies to a crystalline mass. Almost insoluble in water, soluble in alcohol and ether.

HYDROCARBONS. C_nH_{2n}.

712. *Which is the most important member of this series?*

Ethylen, C_2H_4; also known as olefiant gas, elayl, or heavy carburetted hydrogen.

713. *Of what industrial product is it the most important constituent?*

Illuminating gas.

714. *State its properties.*

It is a colorless gas, having a peculiar, disagreeable odor; it burns with a luminous flame and forms explosive mixtures with air and oxygen. It produces deleterious effects when inhaled. When a mixture of equal volumes of this gas and chlorine is allowed to stand, the two substances unite directly to form an oily liquid having the composition $C_2H_4Cl_2$, known as "Dutch liquid."

715. *What series of alcohols correspond to these hydrocarbons? Explain their constitution.*

The glycols. These hydrocarbons possess two unsatisfied valences, and behave as divalent radicals $(C_2H_4)''$; as such they form a series of compounds similar to those of the alcoholic radicals,

with the difference that they replace a double atom of hydrogen in the double molecule of the type:

$$\begin{matrix}(C_2H_4)''\\ Cl_2\end{matrix}\Big\} \qquad \begin{matrix}(C_2H_4)''\\ H_2\end{matrix}\Big\} O_2$$

DIBASIC ACIDS.

NOTE.—As with the monotomic alcohols, so with the diatomic alcohols of this series we may produce acids by substituting oxygen for the hydrogen of the radical, and by this oxidation two series of acids are formed. In the first series, one atom of oxygen takes the place of two atoms of hydrogen in the radical.

$$\begin{matrix}(C_2H_4)''\\ H_2\end{matrix}\Big\} O_2 \qquad \begin{matrix}(C_2H_2O)''\\ H_2\end{matrix}\Big\} O_2$$

Glycol. Glycolic acid.

In the second series, the oxidation is carried further, and two atoms of oxygen take the place of four atoms of hydrogen.

$$\begin{matrix}(C_2H_4)''\\ H_2\end{matrix}\Big\} O_2 \qquad \begin{matrix}(C_2O_2)''\\ H_2\end{matrix}\Big\} O_2$$

Glycol. Oxalic acid.

The members of both of these series of acids have two atoms of extraradical hydrogen capable of being replaced by a metal, and are therefore dibasic.

DIBASIC ACIDS. SERIES $C_nH_{2n}O_3$, $\begin{matrix}C_nH_{2n-2}O\\ H_2\end{matrix}\Big\} O_2$

Carbonic acid (?)	CO_3H_2
Glycolic "	$C_2H_2O_3H_2$
Lactic "	$C_3H_4O_3H_2$
Butylactic "	$C_4H_6O_3H_2$
Leucic "	$C_6H_{10}O_3H_2$

716. *In what important substances does the radical of carbonic acid $(CO)''$ exist?*

In carbon monoxide, carbon dioxide, the carbonates, cyanic acid, and urea.

717. *Does carbonic acid exist free in nature?*

It does not; the substance usually designated by this name is the corresponding anhydride.

718. *What compounds of carbon and oxygen exist free?*

Carbon monoxide CO = Carbonic oxide.

" dioxide CO_2 = " anhydride.

719. *Under what conditions is carbon monoxide formed?*

When coal is burnt with an insufficient supply of air; it is formed abundantly in open charcoal fires, such as are used by tinsmiths, and is the toxic agent in charcoal asphyxia.

720. *State its properties.*

A colorless, odorless gas, almost insoluble in water; burns with a pale blue flame, with formation of carbon dioxide. It is poisonous, and produces death by forming with the blood coloring-matter a compound which prevents the entrance of oxygen into the system.

721. *Give the main physical properties of carbon dioxide.*

Under ordinary conditions of pressure and temperature a colorless, odorless gas, having a faint acid taste; under the influence of increased pressure and diminished temperature it forms a liquid which is very volatile, and which solidifies at $-79°$. Gaseous CO_2 will neither burn nor support combustion. It is soluble in water, the quantity dissolved increasing with the pressure.

722. *In what proportion does CO_2 exist in air?*

About 4 in 10,000.

723. *What are the chief sources of atmospheric CO_2?*

1. Combustion. 2. Respiration of animals. 3. Fermentation. 4. Lime burning. 5. Mineral springs.

724. *Why does it not accumulate in the air?*

Because it is absorbed by plants under the influence of sunlight, and by them decomposed, the carbon entering into the various organic substances produced by the plant.

725. *What action has pure CO_2 when inhaled?*

It produces spasm of the glottis and almost immediate death.

726. *In what two ways may the proportion of CO_2 in air be increased?*

1. By the addition of CO_2 to normal air, as in the processes of fermentation and lime burning. 2. By the oxidation in air of a substance containing carbon, as in the processes of combustion and respiration.

727. *Which of these most rapidly renders air unfit for respiration, and why?*

The second; because not only is the deleterious gas increased, but it is formed at the expense of the oxygen, which is correspondingly diminished.

728. *How does air coming from the lungs differ from inspired air?*

The proportion of oxygen is diminished, while that of carbon dioxide and vapor of water is increased.

729. *What proportion of CO_2 is contained in expired air?*

About 4 per cent. in volume.

730. *What proportion of oxygen is absorbed from the air in passing through the lungs?*

About 5 per cent. in volume.

731. *How do candles and gas lights compare with human beings in the quantity of oxygen which they consume, and of carbon dioxide which they produce?*

A candle about equals an adult man in the quantity of oxygen consumed, and of carbon dioxide produced in its combustion. An ordinary gas-burner is equal to ten adults.

732. *What is "soda water"?*

Water holding in solution a large quantity of CO_2 under the influence of pressure. The gas escapes in bubbles when the pressure is removed.

733. *How is carbon dioxide obtained?*

By decomposing a carbonate by an acid:

$$\underset{\text{Sodic carbonate.}}{CO_3Na_2} + \underset{\text{Hydrochloric acid.}}{2HCl} = \underset{\text{Sodium chloride.}}{2NaCl} + \underset{\text{Water.}}{H_2O} + \underset{\text{Carbon dioxide.}}{CO_2}$$

734. *By what tests is it recognized?*

By the formation of a white precipitate when it is bubbled through lime-water. By being absorbed when confined over a solution of potassium hydrate.

735. *Explain the constitution of the carbonates.*

Although free carbonic acid $\left.\begin{matrix}(CO)''\\H_2\end{matrix}\right\}O_2$ does not exist, the corresponding salts are widely diffused in nature. As the acid is dibasic, the univalent metals form with it two series of salts, in one of which only one atom of hydrogen is replaced by a metal, and in the other both. With the divalent metals only one series of salts is possible.

$$\left.\begin{matrix}(CO)''\\H\\Na'\end{matrix}\right\}_2O \qquad \left.\begin{matrix}(CO)''\\Na_2\end{matrix}\right\}O_2 \qquad \left.\begin{matrix}(CO)''\\Ca''\end{matrix}\right\}O_2$$

736. *By what names are the two series of carbonates of univalent metals distinguished?*

Those in which only one H is replaced are called hydro-metallic carbonates. Thus: $\left.\begin{matrix}(CO)'' \\ H \\ Na\end{matrix}\right\} O_2 =$ hydrosodic carbonate. Those of the other series are designated as metallic carbonates. Thus: $\left.\begin{matrix}(CO)_2 \\ Na_2\end{matrix}\right\} O =$ Sodic carbonate. The hydrocarbonates are also known as bicarbonates, or acid carbonates.

737. *Under what other names is sodic carbonate known, and what is its formula?*

Sodæ carbonas, U. S. P., carbonate of soda, washing soda, sal sodæ. CO_3Na_2.

738. *Explain the process of manufacturing sodic carbonate.*

1. Chloride of sodium is converted into the sulphate by the action of sulphuric acid and heat:

$$\underset{\text{Sodium chloride.}}{2NaCl} + \underset{\text{Sulphuric acid.}}{SO_4H_2} = \underset{\text{Sodic sulphate.}}{SO_4Na_2} + \underset{\text{Hydrochloric acid.}}{2HCl}$$

The HCl formed is dissolved in water, and forms a bye product. 2. The sulphate is mixed with coal and limestone, and heated, when:

$$\underset{\text{Sodic sulphate.}}{SO_4Na_2} + \underset{\text{Calcium carbonate.}}{CO_3Ca} + \underset{\text{Carbon.}}{C_4} = \underset{\text{Calcium sulphide.}}{CaS} + \underset{\text{Sodic carbonate.}}{CO_3Na_2} + \underset{\text{Carbon monoxide.}}{4CO}$$

3. The mass resulting from 2, and known as "black ash," is treated with water, which dissolves out the carbonate. The solution, separated from CaS and C, on evaporation, yields crude carbonate

containing caustic soda. 4. This is mixed with a small quantity of sawdust and roasted, the product being the soda ash, soda, or alkali of commerce. When desired in crystals (soda crystals—washing soda), a hot solution is made and allowed to cool very slowly.

739. *Of what importance is this substance in the arts?*

It is manufactured in large quantities, and is used in many important industrial operations, *e. g.*, glass and soap manufacture, calico printing, and as a starting-point in obtaining the various compounds of sodium. It is used in the laundry to soften hard water. (See Q. 753.)

740. *State the properties of sodic carbonate.*

Large crystals containing 10Aq, or a white powder which absorbs water from the air. Soluble to an almost unlimited extent in hot, and quite soluble in cold water. Disagreeable alkaline taste. Poisonous in large quantity.

741. *How is hydro-sodic carbonate prepared?*

By treating sodic carbonate with carbon dioxide in presence of water:

$$\underset{\text{Sodic carbonate.}}{CO_3Na_2} + \underset{\text{Carbon dioxide.}}{CO_2} + \underset{\text{Water.}}{H_2O} = \underset{\text{Hydro-sodic carbonate.}}{2CO_3NaH}$$

742. *State its properties.*

Crystallizes in hard plates without Aq. Permanent in air, odorless, has a mild alkaline taste, less soluble in water than CO_3Na_2.

743. *How are the carbonates of potassium and sodium formed in the economy, and what is their function?*

By the oxidation of sodium and potassium salts

of other organic acids existing in plants. Their main function is the preservation of alkaline reaction of the circulating fluids.

744. *What is the* potash *or* pearlash *of commerce?*

An impure potassic carbonate, obtained principally from wood ashes.

745. *How is pure CO_3K_2 obtained?*

By decomposing hydro-potassic carbonate by heat:

$$2CO_3KH = CO_3K_2 + CO_2 + H_2O$$

Hydropotassic carbonate. — Potassic carbonate. — Carbon dioxide. — Water.

746. *State its properties.*

A white, crystalline, or granular powder; very soluble in water, deliquescent, insoluble in alcohol. Has a sharp alkaline taste.

747. *Give the method of preparing hydro-potassic carbonate, and its properties.*

Prepared as the corresponding sodium compound. Forms colorless, transparent crystals, soluble in four parts of cold water, insoluble in alcohol. Has an alkaline taste and slight alkaline reaction.

748. *For what household purpose is it used, and with what effect?*

Under the name saleratus in baking bread, etc. When subjected to heat it is decomposed, and the resulting carbon dioxide "raises" the bread, while the remaining potassic carbonate is a very fruitful cause of dyspepsia.

749. *What are the properties and probable composition of ammonii carbonas, U. S. P.?*

White, fibrous masses, having a strong odor of ammonia, and strong alkaline taste, soluble in water. On exposure to air it is decomposed. It

is probably a compound of one molecule of ammonic carbonate and two molecules of hydro-ammonic carbonate, with loss of one molecule of water; its composition is $C_3O_8(NH_4)_4$.

750. *In what forms does calcium carbonate occur in nature?*

Exceedingly abundant as marble, limestone, chalk and calc spar, and in almost all natural waters and soils, in juices of plants, the shells of mollusks and crustacea, bones, teeth and animal fluids, coral, and pearls.

751. *How is it prepared artificially, and by what name is it then known?*

By adding sodic carbonate to solution of calcium chloride. Calcis carbonas præcipitata, U. S. P. Precipitated chalk.

752. *State the properties of calcium carbonate.*

An amorphous white powder, odorless, tasteless, very sparingly soluble in pure water, much more soluble in water containing carbon dioxide. When strongly heated CO_2 is driven off and quicklime remains.

753. *What does "hardness" in water depend on?*

On the presence of carbonates of magnesium and calcium, which are held in solution by carbon dioxide. When hard water is boiled, CO_2 is driven off and the carbonates are in great part precipitated. Water is also rendered hard by the presence of magnesium and calcium sulphates; this is called permanent hardness, as it is not removed by boiling the water, although it may be remedied by the addition of sodium carbonate.

754. *How is magnesiæ carbonas, U. S. P., prepared, and what is its composition?*

By adding solution of sodic carbonate to solution magnesium carbonate. It is a basic carbonate, *i. e.*, a carbonate combined with hydrate, $3CO_3Mg$, MgH_2O_2.

755. *What is white lead?*

A mixture of several basic carbonates of lead.

756. *How is ferrous sub-carbonate prepared?*

By mixing solutions of ferrous sulphate and sodic carbonate.

757. *What is the purpose of the sugar in the Pil. ferri carbonatis, U. S. P.?*

The sub-carbonate is very prone to oxidation, which is, to a great extent, prevented by the presence of sugar.

758. *What compound of carbon and sulphur resembles carbon dioxide in its constitution?*

Carbon disulphide CS_2, or sulphocarbonic anhydride.

759. *What are its properties?*

Clear, colorless liquid, refracting light strongly, having a disagreeable, penetrating odor and sharp taste; heavier than water, with which it does not mix; volatile at ordinary temperatures, boils at 42°; has not been solidified; burns readily, forms an explosive mixture with air; good solvent for fats, resins and india rubber.

760. *Explain what are meant by* amines, amides, *and* imides.

They are organic substances constructed on the ammonia type, $\left.\begin{matrix} H \\ H \\ H \end{matrix}\right\}N$, and may be considered as molecules of ammonia in which the hydrogen has

been, to a greater or less extent, replaced by organic radicals. If the radical contain no oxygen, the resulting compound is called an *amine*, thus:

$$\left.\begin{matrix}H\\H\\H\end{matrix}\right\}N \qquad \left.\begin{matrix}(C_2H_5)'\\H\\H\end{matrix}\right\}N \qquad \left.\begin{matrix}(C_2H_5)'\\(C_2H_5)'\\H\end{matrix}\right\}N \qquad \left.\begin{matrix}(C_2H_5)'\\(C_2H_5)'\\(CH_3)'\end{matrix}\right\}N$$

Ammonia. Ethylamine. Diethylamine. Diethyl-methyl-amine.

So the radical of a monobasic acid may replace one, two or three atoms of the hydrogen of ammonia; in this case the substance is called an *amide*. In the case of the radicals of the dibasic acids (which are divalent) two cases may arise. Either: 1. One radical may replace two atoms of hydrogen in a double molecule of ammonia. Thus:

$$\left.\begin{matrix}H_2\\H_2\\H_2\end{matrix}\right\}N_2 \qquad \left.\begin{matrix}(CO)''\\H_2\\H_2\end{matrix}\right\}N_2$$

Such a substance is called an *amide;* or, 2. The divalent radical may replace two atoms of hydrogen in a single molecule of ammonia:

$$\left.\begin{matrix}H\\H\\H\end{matrix}\right\}N \qquad \left.\begin{matrix}(CO)''\\H\end{matrix}\right\}N$$

forming what is known as an *imide.*

761. *Under what names is the amide of carbonic acid known, and what is its constitution?*

Carbamide, Urea. $\left.\begin{matrix}(CO)''\\H_4\end{matrix}\right\}N_2$

762. *Give the principal physical properties of urea.*

Crystallizes in transparent needles or four-sided prisms, without water of crystallization; permanent in air; odorless, having a cooling, slightly

bitter taste resembling that of saltpetre. Soluble in an equal weight of cold water, very soluble in boiling water, and in five parts of cold or one part of hot alcohol, the solutions being neutral in reaction. At 120° melts, and slightly above that temperature is decomposed.

763. *In what animal fluids is urea found?*

In the blood, lymph, humors of the eye, perspiration, and especially in the urine.

764. *What is the source of urea in the economy?*

The oxidation of albuminoid substances. [It has been shown that urea is formed by the oxidation of albuminoid substances out of the body by means of potassium permanganate.]

765. *What occurs when an aqueous solution of urea is long heated?*

Urea takes up the elements of two molecules of water, and is converted into ammonic carbonate:

$$\underset{\text{Urea.}}{CON_2H_4} + \underset{\text{Water.}}{2H_2O} = \underset{\text{Ammonic carbonate.}}{CO_3(NH_4)_2}$$

766. *Under what other conditions does this change occur?*

Under the influence of certain ferments, and of decomposing animal matter. When urea is heated with a base, or with an acid. When a base is used ammonia is liberated, and a carbonate formed:

$$\underset{\text{Urea.}}{CON_2H_4} + \underset{\substack{\text{Potassium}\\\text{hydrate.}}}{2KHO} = \underset{\text{Ammonia.}}{2NH_3} + \underset{\substack{\text{Potassium}\\\text{carbonate.}}}{CO_3K_2}$$

When an acid is used carbon dioxide is given off, and an ammoniacal salt remains:

$$\underset{\text{Urea.}}{CON_2H_4} + \underset{\substack{\text{Sulphuric}\\\text{acid.}}}{SO_4H_2} + \underset{\text{Water.}}{H_2O} = \underset{\substack{\text{Ammonic}\\\text{sulphate.}}}{SO_4(NH_4)_2} + \underset{\substack{\text{Carbon}\\\text{dioxide.}}}{CO_2}$$

767. *What effect have chlorine, bromine, and nitrous acid upon urea?*

Chlorine and bromine, and the hypochlorites and hypobromites decompose urea with formation of hydrochloric acid, carbon dioxide and nitrogen:

$$\underset{\text{Urea.}}{CON_2H_4} + \underset{\text{Water.}}{H_2O} + \underset{\text{Chlorine.}}{3Cl_2} = \underset{\text{Hydrochloric acid.}}{6HCl} + \underset{\text{Carbon dioxide.}}{CO_2} + \underset{\text{Nitrogen.}}{N_2}$$

Nitrous acid (or nitric acid charged with the lower oxides of nitrogen) produces an oxidation of urea:

$$\underset{\text{Urea.}}{2CON_2H_4} + \underset{\text{Oxygen.}}{3O_2} = \underset{\text{Water.}}{4H_2O} + \underset{\text{Carbon dioxide.}}{2CO_2} + \underset{\text{Nitrogen.}}{2N_2}$$

768. *What occurs when pure nitric or oxalic acid is added to a cold concentrated solution of urea?*

The nitrate or oxalate of urea is formed, and, as these are much less soluble than urea, they separate as crystals.

769. *What is the composition of the imide of carbonic acid, and by what other name is it known?*

$\left.\begin{matrix}CO\\H\end{matrix}\right\}N$ = cyanic acid. [The hydrogen may be replaced by a metal to form a cyanate.]

770. *What occurs when ammonium cyanate is heated?*

It is converted into urea by a simple transposition of atoms:

$$\underset{\text{Ammonium cyanate.}}{\left.\begin{matrix}(CO)''\\NH_4\end{matrix}\right\}N} = \underset{\text{Urea.}}{\left.\begin{matrix}(CO)''\\H_4\end{matrix}\right\}N_2}$$

NOTE.—This reaction has great historical interest; it was performed by Woehler in 1828, and was the first instance in which an organic compound was obtained synthetically.

771. *What compound bears the same relation to cyanic acid as carbon disulphide does to carbon dioxide?*

Sulphocyanic acid, the relation appears from the formulæ:

$\left.\begin{matrix}(CS)'' \\ S\end{matrix}\right\}$ Carbon disulphide.

$\left.\begin{matrix}(CO)'' \\ O\end{matrix}\right\}$ Carbon dioxide.

$\left.\begin{matrix}(CS)' \\ H\end{matrix}\right\} N$ Sulphocyanic acid.

$\left.\begin{matrix}(CO)' \\ H\end{matrix}\right\} N$ Cyanic acid.

772. *For what purpose is potassium or ammonium sulphocyanate used in the laboratory?*

As a test for the ferric compounds with which they form a blood red color, due to the production of ferric sulphocyanate.

773. *Of what are the toys called Pharaoh's serpents composed?*

Mercuric sulphocyanate.

774. *How many lactic acids are there, and what are they?*

Two. Ordinary lactic acid, or lactic acid of fermentation, and sarcolactic, or paralactic acid.

775. *How is the first formed?*

By a peculiar fermentation, known as the lactic, of sugars, in sour milk, and in a variety of other fermented products, as in sauerkraut and some kinds of pickles. It also exists in the gastric juice during digestion of vegetable food, but is not a constituent of the pure fluid.

776. *State its characters.*

It is a clear, sirupy liquid, having a slight, not

unpleasant odor and a sour taste; it is heavier than water, with which it mixes in all proportions, as well as with alcohol and ether. It is a strong monobasic acid, although it contains two extra-radical atoms of hydrogen.

777. *Where does sarcolactic acid occur?*

In the juices of muscular tissue, bile, and in the urine in phosphorous poisoning.

DIBASIC ACIDS. SERIES $C_nH_{2n-2}O_4$.

$$\left.\begin{matrix} C_nH_{2n-4}O_2 \\ H_2 \end{matrix}\right\} O_2.$$

Oxalic acid.....	$C_2O_4H_2$
Malonic "	$C_3H_2O_4H_2$
Succinic "	$C_4H_4O_4H_2$
Pyrotartaric acid.....	$C_5H_6O_4H_2$
Adipic "	$C_6H_8O_4H_2$
Suberic "	$C_8H_{12}O_4H_2$
Anchoic "	$C_9H_{14}O_4H_2$
Sebacic "	$C_{10}H_{16}O_4H_2$
Brasylic "	$C_{11}H_{18}O_4H_2$
Rocellic "	$C_{17}H_{30}O_4H_2$

778. *What is the composition of oxalic acid, and how does it occur in nature?*

$\left.\begin{matrix} C_2O_2 \\ H_2 \end{matrix}\right\} O_2 = C_2O_4H_2$. It exists, in combination with K, Na, and Ca, in many vegetables, to which it gives a sour taste: sorrel, pie-plant, etc.

779. *How is it prepared industrially?*

By the oxidation of starch, sugar, wood or other organic matter, by potassium hydrate, or by nitric acid.

780. *Describe its properties.*

Crystallizes in colorless, odorless prisms, with 2Aq; is permanent in air; has a sour taste; soluble in 8 parts cold, and much more soluble in hot water, as well as in alcohol and ether. It is a strong dibasic acid; its solutions have a strong acid reaction and act as corrosives upon animal tissues. Poisonous.

781. *What treatment should be followed in oxalic acid poisoning?*

Chalk or plaster of Paris should be administered as rapidly as possible; water should be allowed only in small quantities, and warm water should never be used to promote emesis. Avoid using the stomach-pump.

782. *Why are the alkalies not used in this case as in the cases of the mineral acids?*

Because they form salts which are as soluble and as poisonous as the acid itself; while the calcium compounds form the insoluble calcium oxalate.

783. *What action has oxalic acid upon cloth and writing ink?*

It forms a brown stain upon cloth, and bleaches writing ink. Writing removed by oxalic acid may be restored in blue by moistening with solution of potassium ferrocyanide.

784. *Give tests for oxalic acid and the soluble oxalates.*

Calcium chloride added to the solution, neutralized with ammonium hydrate, forms a white crystalline precipitate, which is insoluble in acetic but soluble in hydrochloric acid; the same precipitate is formed with lime-water, or solution of

calcium sulphate. Silver nitrate, in neutral solution, forms a white precipitate, which is easily soluble in nitric acid. This precipitate does not darken when the fluid is boiled, but when dried and heated explodes.

785. *Explain the constitution of the oxalates.*

Oxalic acid, being dibasic, $\left.\begin{matrix}C_2O_2\\H_2\end{matrix}\right\}O_2$, forms with the univalent metals two series of salts, $\left.\begin{matrix}C_2O_2\\M'\\H\end{matrix}\right\}O_2$ and $\left.\begin{matrix}C_2O_2\\M'_2\end{matrix}\right\}O_2$, and with the divalent metals a single series, $\left.\begin{matrix}C_2O_2\\R''\end{matrix}\right\}O_2$.

786. *Give the formula and synonyms of hydropotassic oxalate.*

$\left.\begin{matrix}C_2O_2\\KH\end{matrix}\right\}O_2 = C_2O_4HK$. Acid oxalate, or binoxalate of potash, salt of lemons, salt of sorrel.

787. *For what purpose is ammonic oxalate used in analysis?*

As a test for the calcium compounds.

788. *What is the formula and common name of calcium oxalate?*

$\left.\begin{matrix}C_2O_2\\Ca\end{matrix}\right\}O_2 = C_2O_4Ca =$ Oxalate of lime.

789. *Is calcium oxalate a normal or pathological constituent of the urine?*

Normal.

790. *The oxalate of what rare metal is used in medicine?*

Cerium oxalate.

OTHER ACIDS DERIVED FROM DIATOMIC ALCOHOLS.

791. *Where do the malates exist in nature?*

In the juices of many fruits—apples, currants, etc.

792. *What is the constitution and basicity of tartaric acid?*

$\left.\begin{matrix}(C_4H_2O_2)^{iv} \\ H_4\end{matrix}\right\} O_4 = C_4H_6O_6$. Although it has four atoms of extraradical hydrogen, it always behaves as a dibasic acid.

NOTE.—There exist a number of acids which present this peculiarity. Thus: Lactic acid contains two atoms of extraradical hydrogen; of these only one may be replaced by metal in the manner in which salts are formed. The other atom of hydrogen behaves like the corresponding hydrogen in an alcohol, and can only be replaced by a radical or by the alkaline metals. In short, these compounds are in their functions half alcohol and half acid. This is expressed in the case of lactic acid, by saying that it is monobasic and diatomic. So tartaric acid is dibasic and tetratomic.

793. *State the properties of tartaric acid.*

Crystallizes in large, hard, transparent prisms; odorless; having a strong, sour, but not disagreeable taste. Very soluble in water; soluble in alcohol. The aqueous solution becomes mouldy on standing.

794. *Give the composition of seidlitz powders, and explain the reaction which occurs when their solutions are mixed.*

The powder in the blue paper is a mixture of Rochelle salt (q. v.) and hydro-sodic carbonate; the white paper contains tartaric acid. When the solutions are mixed, the carbonate is decomposed

by the acid; sodic tartrate remains in the solution, while the liberated carbon dioxide produces the effervescence.

795. *Give an account of the source of tartaric acid and the tartrates.*

The tartrates exist in the juice of the grape in notable quantities, and are obtained industrially as a bye product in the manufacture of wine. During the fermentation of wine the must becomes more and more alcoholic, and the hydro-potassic tartrate which it contains, being less soluble in alcoholic fluids than in water, is gradually deposited, forming the crude tartar, or "argol" of commerce.

796. *What are the chemical name and characters of cream of tartar?*

Hydro-potassic tartrate, obtained by purifying crude tartar. A white crystalline powder, odorless, having a sourish taste; soluble in 180 parts of cold and in 20 parts of hot water; insoluble in alcohol.

797. *How is Potassæ tartras, U. S. P., formed, and what is its chemical name?*

By adding hydro-potassic tartrate to solution of potassic carbonate, when carbon dioxide is liberated and potassic tartrate, $C_4H_4O_6K_2$, is formed.

798. *In what important physical character does it differ from hydro-potassic tartrate, and how?*

It is very soluble in water, while the hydro-salt is only sparingly soluble. It has hence received the common name of soluble tartar.

799. *What is the composition of Rochelle salt?*

It is a double tartrate of potassium and sodium, $\left.\begin{matrix}C_4H_2O_2\\H_2NaK\end{matrix}\right\}O_4$

800. *What is the composition of tartar emetic?*

It is a double tartrate of potassium and the radical $(SbO)'$, $H_2\,(SbO)'K\left\{\begin{matrix}C_4H_2O_2\\ \\ O_4\end{matrix}\right.$, or antimonyl-potassic tartrate.

801. *State its properties.*

It forms shining, colorless, transparent prisms with 1Aq, or a white powder; odorless; having a sweetish, unpleasant, metallic taste; soluble in 15 parts cold or 2 parts hot water.

802. *What antidote should be given in tartar emetic poisoning?*

Tannic acid, or some substance containing it—such as tea, infusion of oak bark, cinchona. The object is the production of an insoluble compound.

803. *Whence is citric acid obtained, and what are its characters?*

From lemon juice. It forms large, colorless crystals, with 1Aq, having a strong acid taste; very soluble in water, the solution becoming mouldy by keeping. It is a tribasic acid.

804. *What is the chemical name of Potassæ citras, U. S. P., and in what preparations does it occur?*

Tripotassic citrate. In Liq. potass. citratis, and Mistura pot. citr.

TRIATOMIC ALCOHOLS.

805. *What important triatomic alcohol is known? Explain its constitution.*

Glycerin; $C_3H_8O_3$. A monoatomic alcohol may be regarded as a molecule of water, in which one atom of hydrogen is replaced by an univalent radical: $H\,(C_2H_5)'\left\{\begin{matrix}\\ \\ O\end{matrix}\right.$; a diatomic alcohol as a dou-

ble molecule of water, in which a double atom of hydrogen has been replaced by a divalent radical: $\left.\begin{matrix}(C_2H_4)''\\ H_2\end{matrix}\right\}O$; and a triatomic alcohol as a triple molecule of water, in which a triple atom of hydrogen has been replaced by a trivalent radical: $\left.\begin{matrix}(C_3H_5)'''\\ H_3\end{matrix}\right\}O_3$ = glycerin.

806. *Give the characters of glycerin.*

A colorless, odorless, sirupy liquid; neutral in reaction; miscible in all proportions with water; having a sweetish taste; not altered by exposure to air.

807. *Explain the constitution of the fats.*

They are ethers of glycerin with certain monobasic acids of the series $C_nH_{2n}O_2$. The compound ethers may be regarded as alcohols in which the extraradical hydrogen is replaced by an acid radical. As glycerin is triatomic (*i. e.*, has three atoms of extraradical hydrogen), three ethers of glycerin with the monobasic acids exist. Thus, with stearic acid, $\left.\begin{matrix}C_{18}H_{35}O\\ H\end{matrix}\right\}O$, we have:

$\left.\begin{matrix}(C_3H_5)'''\\ H_3\end{matrix}\right\}O_3$
Glycerin.

$\left.\begin{matrix}(C_3H_5)'''\\ H_2\\ (C_{18}H_{35}O)'\end{matrix}\right\}O_3$
Monostearin.

$\left.\begin{matrix}(C_3H_5)'''\\ H\\ (C_{18}H_{35}O)'_2\end{matrix}\right\}O_3$
Distearin.

$\left.\begin{matrix}(C_3H_5)'''\\ (C_{18}H_{35}O)_3\end{matrix}\right\}O_3$
Tristearin.

The neutral animal fats are composed of mixtures, in varying proportions, of three such ethers, viz.

Tristearin, tripalmitin and triolein, with small quantities of other similar bodies.

808. *How do these three differ from each other in their physical properties?*

The two former are solid and the latter liquid at ordinary temperatures. Tristearin melts at 61°, and tripalmitin at 46°. The fluid fats or oils contain the greatest proportion of triolein.

809. *What is an emulsion?*

A liquid fat in a state of fine and permanent subdivision and suspension in a watery fluid. Oil and water will not mix under ordinary conditions; but if small quantities of certain other substances—such as albumen or pancreatin—be added, and the two liquids shaken together, an emulsion is formed.

810. *Explain the process of saponification.*

It is a double decomposition between a fat and an alkali, in which the metallic salt of the acid and glycerin are formed:

$$\underset{\text{Tristearin.}}{\left.\begin{matrix}(C_3H_5)'''\\(C_{18}H_{35}O)'_3\end{matrix}\right\}O_3} + \underset{\text{Potassium hydrate.}}{3\left\{\begin{matrix}K\\H\end{matrix}\right.O} = \underset{\text{Glycerin.}}{\left.\begin{matrix}(C_3H_5)'''\\H_3\end{matrix}\right\}O_3} + 3\underset{\text{Potassium stearate.}}{\left\{\begin{matrix}(C_{18}H_{35}O)\\K\end{matrix}\right.O}$$

811. *What is the source of the fats in the body?*

They are, to a great extent, taken with the food in their own form, but are also formed in the body from starchy and saccharine substances, and even from albuminous substances. Animals may be fattened on food which contains little fat, but is rich in starch.

812. *What changes do fats undergo in the economy?*

They are oxidized, and their component elements are finally discharged as carbon dioxide and water. It is highly probable that this oxidation is not direct, but that certain substances are formed during the process, intermediate between the fats and the final products. This oxidation in the body is attended by the liberation of force and heat; a fatty diet is, therefore, eminently suited to cold climates, as it maintains the body temperature in two ways: 1st, by the liberation of heat in its oxidation; and 2d, by preventing the loss of heat, the layer of fat between the skin and the tissues acting as a non-conductor.

813. *State the prominent physical properties of fats.*

They are lighter than water, with which they do not mix. When liquid fats are shaken with water they form globules of varying size, circular in outline, and refract light strongly. (When an oil globule is examined with the microscope it appears as a disk, having a dark border and a bright centre. As the distance between the glass and object is increased, the centre becomes brighter and the border darker.) They are soluble in ether, to a certain extent in alcohol, and in solutions of the alkalies with formation of soaps. They produce a translucent stain on paper.

814. *What is a soap, and what is the chemical difference between hard and soft soap?*

A mixture of the stearate, palmitate, and oleate of sodium or potassium. The sodium compounds form the hard soaps, and the potassium compounds soft soap.

815. *What is the constitution of nitroglycerin?*

Similar to that of the fats, but in place of radicals of the fatty acids, it contains the radical of nitric acid. It is the trinitric ether of glycerin: $\left.\begin{matrix}(C_3H_5)'''\\(NO_2)_3\end{matrix}\right\}O_3$

816. *Is cholesterin related to the fats, and what is its constitution?*

It is not. It is an alcohol, having the composition $\left.\begin{matrix}(C_{26}H_{43})'\\H\end{matrix}\right\}O$

817. *State the physical characters of cholesterin.*

A white solid, crystallizing in plates or needles; tasteless, odorless, unctuous to the touch, insoluble in water, sparingly soluble in cold alcohol, and readily in hot alcohol or ether. Melts at 145°.

818. *Give some of the reactions of cholesterin.*

Treated with nitric acid, the solution evaporated nearly to dryness and ammonium hydrate added; a brick-red color. With sulphuric acid and chloroform, a red color, changing to violet, blue, green. Not affected by potash solution.

819. *In what parts of the economy does it occur?*

In blood, bile, nerve tissue. Pathologically in gall stones, fluids of hydrocele and of certain cysts; tumors, consisting almost entirely of cholesterin, have occurred in the brain.

CARBOHYDRATES.

820. *What are the characters of substances of this class?*

Substances composed of C, H, and O, the last two being in the proportion to form water, *i. e.*,

H_2 to O; but few of them have been obtained artificially, and nearly all exist in vegetable and animal bodies. Their constitution is not yet determined, although it is highly probable that they are alcohols.

821. *Into what three groups may they be divided?*

1. Glucose group. 2. Cane sugar group. 3. Starch group.

822. *Name the most important member of the first group, and give its synonyms.*

Glucose.—Grape sugar; liver sugar; diabetic sugar; dextrose.

823. *State its chief physical properties.*

Forms yellowish nodules or crystals; very soluble in water and in alcohol; has a sweet taste, less marked than that of cane sugar.

824. *How may it be obtained artificially?*

From cane sugar or starch; either, 1, by boiling with a dilute mineral acid; or, 2, by the action of a vegetable ferment, called diastase, which is formed during the germination of grain.

825. *What action have boiling solutions of the alkalies upon glucose?*

They convert it into a brown substance, having the odor of molasses, known as mellassic acid.

826. *Give the formulæ of grape and cane sugars.*

Grape sugar, $C_6H_{12}O_6$; cane sugar, $C_{12}H_{22}O_{11}$.

827. *What are the main points of difference between grape and cane sugars?*

Cane sugar is more easily and perfectly crystallizable, more soluble and sweeter than glucose; it also differs from glucose in not being directly capable of fermentation, and in not reacting with the reduction tests for sugar. (See Q. 1014.)

828. *Describe the action of heat on cane sugar.*

When heated to 160° it melts, and, on cooling, forms an amber colored solid known as "barley sugar;" if the heat be continued to 205°, a brown, tasteless mass, known as "burnt sugar" or "caramel" remains; this is tasteless, soluble in water or dilute alcohol, and is largely used to give color to confectionery and spirits.

829. *Where is milk sugar found? Describe its characters.*

In milk. Crystallizes in hard, white prisms. It is the least soluble of all sugars in water, and is insoluble in alcohol; it enters into alcoholic fermentation with difficulty; in presence of decomposing albuminous matter, and under certain other influences, it undergoes a peculiar fermentation, known as the lactic, resulting in the formation of carbon dioxide, alcohol, and lactic acid. It reacts readily with the reduction tests.

830. *Where does starch exist in nature?*

In all plants. The main sources from which it is obtained are potatoes and cereals. It does not exist in animal tissues or fluids.

831. *Give its physical characters.*

It forms a white, shining powder, or, if dried in bulk, columnar masses. When examined microscopically it is found to consist of round, or egg-shaped granules, differing in size and appearance with the source from which it was obtained. When heated, the granules swell and split into concentric layers. Almost insoluble in water, but, if soaked or boiled in water, the granules swell, burst, and finally form a gelatinous mass known as "hydrated starch," or starch paste.

832. *Describe the action of mineral acids on starch.*

When boiled with dilute mineral acids, starch is converted into glucose. Hot concentrated nitric acid converts it into oxalic acid. Cold fuming nitric acid dissolves it, forming an explosive nitro compound.

833. *Give a test for starch.*

Solution of iodine with starch gives a dark, violet-blue color, which disappears on warming and returns on cooling; this reaction is characteristic and very delicate.

834. *What articles of food are composed entirely of starch?*

Sago, tapioca, arrowroot.

835. *What proportion of starch is contained in wheat and rice?*

Wheat contains about 70 per cent.; and rice, 90 per cent.

836. *What action have diastase, ptyalin and pancreatin upon starch?*

They convert it into glucose.

837. *What is cellulose?*

A substance having the same centisimal composition as starch, and forming the basis of all vegetable fibre. It exists almost pure in cotton and Swedish filter paper.

838. *Give the formula of starch and cellulose.*

$C_6H_{10}O_5$.

839. *Explain the action of nitric acid upon cellulose.*

By acids of different concentration one, two, or three times the group (NO_2) replaces one, two, or three atoms of hydrogen of cellulose, to form mono-, di-, and tri-nitro cellulose.

840. *How do these three differ, and for what purposes are they used?*

In the violence with which they explode on being ignited in a confined space; the force of the explosion increasing with the number of groups (NO_2) substituted. Trinitro cellulose is sometimes used as a substitute for gunpowder under the name guncotton; dinitro cellulose, or pyroxylin, dissolved in a mixture of alcohol and ether, forms the collodion used in photography and as a styptic.

841. *Where is glycogen found, and what are its properties?*

In the liver of all animals. It closely resembles starch in its properties; a white, odorless, tasteless, amorphous powder, swells up in cold water, forms an opalescent solution with hot water; does not react with any of the tests for glucose, into which substance it is, however, readily converted by the same agents which convert starch into glucose, as well as by some substance existing in the liver and in blood.

842. *By what reaction may it be distinguished from starch?*

Iodine solution colors it violet-red.

843. *How is dextrin formed, and what are its properties?*

By the action of dilute acids upon starch; it is an intermediate product in the conversion of starch into glucose. It is a transparent, brittle solid, having the appearance of gum, soluble in water and dilute alcohol, insoluble in strong alcohol and in ether. Does not react with the reduction tests for sugar, and is not capable of fermentation; is not colored by iodine. It is used in the arts under the name "British gum."

CYANOGEN COMPOUNDS.

844. *What is the composition and valence of the radical cyanogen?*

(CN). Univalent.

845. *Give the formula, proper name, and properties of cyanogen gas.*

$\left.\begin{matrix}CN\\CN\end{matrix}\right\} = (CN)_2$. Dicyanogen. At ordinary temperatures a colorless gas, having a penetrating odor of bitter almonds; very irritating to the eyes and air passages; very poisonous; soluble in water, alcohol, or ether.

846. *Give the formula and synonyms of hydrogen cyanide.*

$\left.\begin{matrix}CN\\H\end{matrix}\right\}$. Hydrocyanic, or prussic acid.

847. *What is the strength of Acid. Hydrocyan. Dil., U. S. P.?*

2 per cent. of anhydrous acid.

848. *What are its characters?*

A colorless liquid, having an odor of bitter almonds and a bitter taste; very prone to decomposition, especially when exposed to light. Highly poisonous.

849. *What other substances contain hydrocyanic acid?*

Oil of bitter almonds; bitter almond water; cherry laurel water; wild cherry bark, and the kernels of the peach, plum, etc.

850. *Explain the formation of hydrocyanic acid in oil of bitter almonds.*

It does not pre-exist in the almonds, but is

formed by the reaction of two substances known as amygdalin and emulsin (the former does not exist in sweet almonds); this reaction takes place in the preparation of the oil, or, when bitter almonds are eaten, in the mouth and stomach.

851. *Explain the constitution of the cyanides.*

Hydrogen cyanide is an acid, and behaves in a manner similar to hydrochloric acid:

$$\underset{\text{Hydrochloric acid.}}{ClH} + \underset{\text{Potassium hydrate.}}{KHO} = \underset{\text{Potassium chloride.}}{KCl} + \underset{\text{Water.}}{H_2O}$$

$$\underset{\text{Hydrocyanic acid.}}{(CN)H} + \underset{\text{Potassium hydrate.}}{KHO} = \underset{\text{Potassium cyanide.}}{K(CN)} + \underset{\text{Water.}}{H_2O}$$

852. *State the properties and uses of potassium cyanide.*

Hard, dull white, amorphous solid, having an odor of bitter almonds, and an alkaline taste; very soluble in water, sparingly in alcohol. It is decomposed by even the weak acids, with liberation of hydrocyanic acid, and is consequently very poisonous. It is used largely in photography and in electro-plating.

853. *How is argentic cyanide prepared, and what are its characters?*

By passing hydrocyanic acid through a solution of silver nitrate to saturation, and washing the precipitate. A tasteless, white powder; insoluble in water, but soluble in solution of potassium cyanide.

854. *Explain its use in pharmacy.*

To prepare extemporaneously a solution of hydrocyanic acid of known strength. Take 8.3 grams

pure HCl, of sp. gr. 1.16, and dilute with water to make 98 cub. cent., add to this 9.925 grams argentic cyanide; the resulting fluid, separated from the silver chloride by filtration, contains 2 per cent. CNH. [The materials must be pure, and the weighings accurate.]

855. *Give a test for hydrocyanic acid.*

Add a few drops of ammonium hydrosulphide, evaporate over a water-bath, acidulate with dilute hydrochloric acid, and add a drop of solution of ferric chloride; a blood-red color is produced, which disappears upon adding solution of mercuric chloride.

856. *What treatment is to be followed in CNH poisoning?*

There is no time for administration of antidotes by the mouth. Throw cold water on the head, face, and back, rub dry, and repeat the douche. Inhalation of chlorine is beneficial, and ammonia or smelling salts may be used; the chlorine must be largely diluted with air.

857. *Give the method of obtaining potassium ferrocyanide.*

By heating refuse animal matter, containing nitrogen, with potassium carbonate and iron filings.

858. *Under what other name is it known?*

Yellow prussiate of potash.

859. *What are its properties?*

Tough, yellow crystals, easily splitting into laminæ; soluble in water, insoluble in alcohol; having a bitter taste. Dilute acids decompose it with liberation of hydrocyanic acid, a reaction utilized in preparing that substance. Non-poisonous.

860. *What are its uses?*

As the source of all the cyanogen compounds; in the manufacture of Prussian blue; and as a valuable reagent in analysis.

861. *State some of the reactions of potassium ferrocyanide.*

With ferric salts a deep blue precipitate (Prussian blue) in acid solution. With a copper salt a red brown precipitate. With a zinc compound a white precipitate.

862. *How is potassium ferridcyanide prepared, and by what other name is it known?*

By passing chlorine through a solution of potassium ferrocyanide until a sample no longer gives a blue precipitate with a ferric salt. Red prussiate of potash.

863. *What is Turnbull's blue?*

A blue insoluble substance obtained when solutions of potassium ferridcyanide and a ferrous salt are brought together.

URIC ACID AND ITS DERIVATIVES.

864. *Give the formula of uric acid.*

$C_5H_4N_4O_3$. Its constitution is as yet unknown.

865. *In what parts of the body does it occur?*

In the urine of the carnivora and in the excrements of birds, reptiles, and insects; in the blood, spleen, lungs, liver, pancreas and brain. It enters into the composition of many urinary calculi, and the so-called "chalk stones" deposited in the joints in gout.

866. *In what form does it exist?*

It does not occur uncombined in the normal

body, but exists as the urates of sodium and ammonium; principally the former.

867. *What is the source of uric acid in the economy?*

It is a product of the oxidation of albuminous substances, and is probably an intermediate step in the formation of urea.

868. *Give the properties of pure uric acid.*

A light, white powder, composed of small crystals; odorless, tasteless, very sparingly soluble in water, insoluble in alcohol and ether, soluble without decomposition in sulphuric and hydrochloric acids. Moist uric acid has an acid reaction. It is a dibasic acid.

869. *Give a test for the presence of uric acid.*

Moisten with nitric acid and evaporate nearly to dryness, add ammonium hydrate. If uric acid be present the nitric acid residue is yellow, and on addition of the ammonia a brilliant red color is produced.

870. *What substance is formed in this reaction?*

Murexid.

871. *How may uric acid be obtained from urine?*

By adding hydrochloric acid, and allowing the mixture to stand. The HCl unites with the base, and the uric acid thus liberated, being insoluble, is deposited.

872. *How do the crystals obtained by* 871 *differ from those of pure uric acid?*

In being yellow or brown. The coloring matter of the urine adheres tenaciously to uric acid, and it is very difficult to obtain the pure acid from this source. The form of the crystal also differs from that of crystals of the pure acid.

873. *What is the object of administering lithium compounds in diseases attended with excessive production of uric acid?*

Urate of lithium is more soluble than urate of sodium; therefore, if the former salt be formed in the body in place of the latter, there is less danger of the formation of deposits. If deposits have already formed, either in the tissues or as calculi, their solution and removal is aided by the formation of lithium urate.

874. *Where does xanthin occur?*

In the urine and muscular tissue; as the main constituent of certain rare urinary calculi.

875. *What substance, closely related to xanthin, is found in muscular tissue?*

Hypoxanthin or sarkin.

876. *Mention the points of interest connected with kreatin and kreatinin.*

The former is found in voluntary and involuntary muscular tissue. It is more abundant in that of animals that have been hunted than in those that have died quietly. It is a product of disassimilation of the albuminous constituents of muscle. Kreatin occasionally appears in the urine in small quantities, but is usually converted into kreatinin, which is a constant constituent of the urine.

AROMATIC SERIES.

877. *Why is this name given to this series?*

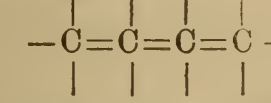
The substances which compose it have strong and aromatic odors; among them are a number of essential oils and substances derived from them.

878. *Of what substance are all the members of this series derivatives?*

Of benzine; C_6H_6.

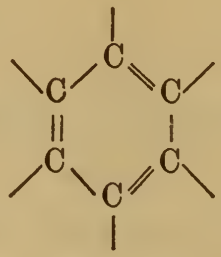
879. *Explain the constitution of benzine, and how the other aromatic substances are derived from it.*

There is a very important difference between the constitution of the aromatic substances and that of those heretofore considered; in the latter the atoms of carbon are arranged in a chain, two valences being interchanged between each two atoms:



The resulting carbon nucleus has therefore $2n+2$ free valences, which may be satisfied by atoms or radicals. In the case of benzine, however, the carbon atoms are arranged differently, and the number of free valences is very much less than in the compounds of the fatty series. The carbon atoms are not arranged in an open, but in a closed

chain, in which the exchange of valences takes place thus:



so that there remain six free valences; when these are all satisfied by hydrogen the resulting substance is benzine; they may, however, be satisfied by other elements or radicals, and thus give rise to a great number of compounds.

880. *Whence is benzine obtained, and what are its uses?*

It is obtained, with other hydrocarbons closely related to it, in large quantities from coal-tar. It is used in painting, as a solvent for many substances rich in carbon. One of its most important uses is as the starting-point in the manufacture of anilin dyes.

881. *State its principal properties.*

It is a colorless liquid; boils at 82°, and solidifies at 4.5°; does not mix with water; burns with a smoky flame. Pure benzine has an agreeable, the commercial article an unpleasant odor.

882. *Explain the action of fuming nitric acid upon benzine.*

An oily liquid is formed, which is nitrobenzol, resulting from the substitution of a group (NO_2) for one of the hydrogens of benzine: $C_6H_5(NO_2)$.

883. *For what purposes is nitrobenzol used?*

It has a pronounced odor of bitter almonds, and is used in perfumery and confectionery under the name "Essence de Mirbane," notwithstanding the fact that it is poisonous when taken by the stomach or when its vapor is inhaled. Its chief use is as a step in the manufacture of anilin dyes.

884. *Explain the formation of anilin from nitrobenzol.*

By the action of reducing agents the group $(NO_2)'$ is displaced, and the group $(NH_2)'$ is substituted to form $C_6H_5\ (NH_2)$ = anilin or amidobenzol.

885. *What is the appearance of anilin?*

A colorless, mobile liquid; having a peculiar disagreeable odor, and sharp, burning taste; heavier than water; boils at 184.8°; becomes brown on exposure to air; poisonous. Its most important property is that of forming various colored derivatives, anilin dyes.

886. *What substance results from the substitution of a group (OH) for an atom of hydrogen in benzine?*

Phenol. Commonly known as carbolic or phenic acid.

887. *State the properties of phenol.*

It crystallizes in long, colorless needles, which melt at 35°. It has a peculiar odor, and a burning, bitter taste. Soluble in 20 parts of water, quite soluble in alcohol and in ether. It is a powerful antiseptic agent, coagulates albumen, and prevents fermentation.

888. *Describe the action of nitric acid upon phenol.*

When the two substances are boiled together three of the atoms of hydrogen of the benzol nucleus are replaced by groups $(NO_2)'$ with formation of trinitrophenol, $C_6H_2(NO_2)_3OH$, commonly known as picric or carbazotic acid.

889. *State the properties of trinitrophenol.*

Forms prismatic, sulphur-yellow crystals, having a strong, bitter taste, sparingly soluble in water, quite soluble in alcohol or ether. It has an acid reaction, and forms salts called picrates. These are all decomposed by heat, usually with an explosion. Its coloring power is very intense and it is used in dyeing.

890. *To what beverages is picric acid fraudulently added, and how may it be detected?*

To malt liquors. Immerse some unbleached wool in the liquid, boil for ten minutes, remove the wool, wash and treat it with hot aqua ammoniæ, evaporate the solution so obtained at 100° to a small volume, and add solution of potassium cyanide. If picric acid be present a red color is produced.

ACIDS OF THE AROMATIC SERIES.

891. *Give the formula and constitution of benzoic acid.*

$C_7H_6O_2$. It is derived from benzine, by the substitution of a group $(COOH)'$ for one atom of hydrogen, C_6H_5,CO_2H. The typical formula is $\left.\begin{matrix}(C_7H_5O)'\\ H\end{matrix}\right\}O$; the radical $(C_7H_5O)'$ being univalent, and the acid monobasic.

892. *How does benzoic acid exist in nature, and how is it obtained?*

It exists in a number of resins and balsams notably in benzoin, from which it is obtained by sublimation. The benzoin is placed in a porcelain capsule, covered with filter paper, over which is a cone of writing-paper. On heating the capsule the acid is volatilized, passes through the filter-paper, and condenses in the cone.

893. *State the properties of benzoic acid.*

It crystallizes in long, white, flexible needles, or in thin laminæ, which fuse at 121° and sublime at 140°. Sparingly soluble in cold water, more soluble in boiling water, easily soluble in alcohol, ether, and the fatty and ethereal oils. When pure it is odorless and has a faint acid taste. [The odor usually observed in commercial benzoic acid is due to the presence of small quantities of a volatile oil.]

894. *What is the composition of the aldehyde corresponding to benzoic acid, and in what oil does it exist?*

$\left.\begin{matrix} C_7H_5O \\ H \end{matrix}\right\}$. Oil of bitter almonds.

895. *Into what substance is benzoic acid converted in passing through the animal economy?*

Hippuric acid.

896. *Give the occurrence and properties of hippuric acid.*

It is found in human urine in small and variable quantities, and abundantly in that of the herbivora. It crystallizes in long, colorless prisms; sparingly soluble in cold, readily soluble in hot water and in alcohol. It is monobasic. When heated alone, when boiled with the mineral acids or alkalies, and

under the influence of certain ferments—as in putrid urine—it is decomposed with formation of benzoic acid.

897. *What is the constitution of salicylic acid?*

It has the same relation to phenol that benzoic acid has to benzine. It is therefore phenol, in which an atom of hydrogen has been replaced by the group $(CO_2H)'$; $C_6H_4,CO_2H,OH=C_7H_6O_3$.

898. *How does it exist in nature, and how is it prepared?*

It exists, as its methylic ether, in oil of wintergreen, from which it may be obtained; it is, however, more cheaply prepared by the combined action of sodium and carbonic anhydride upon phenol.

899. *State its properties.*

It crystallizes in colorless prisms; odorless; has a sweetish, sour taste; fuses at 158°; at 80° it sublimes slowly, more rapidly as the temperature is raised to 200°; at higher temperatures, or when rapidly heated, it is decomposed into phenol and carbon dioxide. Sparingly soluble in cold, readily soluble in warm water and in alcohol or ether; its solutions are acid. It is a monobasic acid. It is a valuable disinfectant.

900. *How is gallic acid obtained?*

By exposing moistened gall-nuts to the air for a month or more; under the influence of a peculiar ferment, the tannic acid of the galls is converted into gallic acid, which is then extracted by subjecting the pasty mass to pressure, and purified by solution, filtration through purified animal charcoal and crystallization.

901. *Give the principal properties of gallic acid.*

It forms white, silky needles with 1Aq, which is driven off at 120°. Odorless, has a sweetish, astringent taste, and an acid reaction; sparingly soluble in cold, readily soluble in hot water, and abundantly soluble in alcohol. It does not precipitate gelatin or the alkaloids from their solutions (distinction from tannin). When heated to 210°, it is decomposed into pyrogallol (=pyrogallic acid) and carbon dioxide.

902. *What are the* tannins *or* tannic acids?

Certain substances of different composition existing in various barks, leaves, etc. They are amorphous bodies, having a faint acid reaction, soluble in water, and astringent. They all precipitate with albumen, the alkaloids, the ferric salts, and they also form with animal substances imputrescible compounds. They exist notably in oak bark, gall-nuts, cinchona, coffee.

903. *Whence is the acidum tannicum, U. S. P., obtained, and what are its chemical name and formula?*

From nutgalls, which are excrescences produced upon the oak by the puncture of an insect. It is distinguished from the other tannins, which differ from it chemically, by the name gallotannic acid. It has the formula $C_{14}H_{10}O_9$, and is considered as being formed by the union of two molecules of gallic acid with less of a molecule of water:

$$\underset{\text{Gallic acid.}}{2C_7H_6O_5} = \underset{\text{Water.}}{H_2O} + \underset{\text{Gallotannic acid.}}{C_{14}H_{10}O_9}$$

904. *Give the prominent properties of gallotannic acid.*

A light, yellowish, amorphous powder, highly

astringent. Readily soluble in water, less so in alcohol, insoluble in ether. It has acid properties, and forms salts which are amorphous.

905. *What class of medicinal substances contain tannin?*

The vegetable astringents.

906. *Why are the alkaloids and tartar emetic incompatible with tannic acid?*

Because insoluble tannates are formed.

907. *What is formed when tannic acid and a ferric compound are brought together?*

Black ink.

OTHER AROMATIC COMPOUNDS.

908. *Name some other aromatic hydrocarbons.*

Naphthalin, anthracen, oil of turpentine.

909. *State the source and uses of naphthalin and anthracen.*

They are both obtained by the distillation of coal-tar; the former is used in the manufacture of certain coal-oil colors, and the latter has assumed commercial importance as the source from which alizarin, the coloring-matter of madder, is now obtained artificially.

910. *How is oil of turpentine obtained?*

A resinous juice, exuded from incisions in certain varieties of pine, and known as crude turpentine, is distilled with water, the volatile spirit or oil of turpentine passes over while rosin remains in the still.

911. *State the prominent properties of oil of turpentine.*

A colorless liquid, having a characteristic odor; lighter than water; boiling at 161°; readily inflammable, burning with a smoky flame; a solvent for phosphorus, sulphur, india-rubber, and many resins. When exposed to the air it assumes a yellow tinge, becomes thicker, and absorbs oxygen.

912. *What varieties of camphor occur in commerce?*

Borneo camphor, or Borneol, and Chinese or Japanese camphor; the latter contains two atoms of hydrogen less than the former.

913. *State the more prominent properties of Japanese camphor.*

White, semi-transparent crystals, having a strong aromatic odor, and a sharp, bitter taste; very volatile; sparingly soluble in water, readily soluble in alcohol, ether, and the oils.

914. *How is indigo obtained?*

There exist in certain plants of the genus Indigofera, a peculiar light yellow substance known as *indican;* the fresh plants are moistened, allowed to ferment, and shaken in the presence of air; under this treatment the indican is split up into *indigotin*, the blue coloring-matter, and a peculiar substance resembling glucose.

SUBSTANCES WHOSE CONSTITUTION IS UNKNOWN.

GLUCOSIDES.

915. *What is the characteristic property of the glucosides?*

That of splitting up under the influence of the acids, alkalies and of certain ferments into a sugar (usually glucose) and some other substance.

916. *Mention some of the more important glucosides, and the sources from which they are obtained.*

Salicin, from willow bark; Arbutin, from uva ursi; Carminic acid, from cochineal; Indican, from the indigo plant; Jalapin, from jalap; Digitalin, from digitalis; Antiarin, from upas; Solanin, from dulcamara; Amygdalin, from bitter almonds; Cerebrin, a constituent of brain tissue.

917. *Give a test for the presence of digitalin.*

Dissolve in concentrated sulphuric acid, a green color is produced; stir the solution with a glass rod moistened with bromine water, the color changes to reddish violet; if the mixture be shaken with ether, the coloration passes into the ethereal layer.

ALKALOIDS.

918. *Mention the distinctive characters of the alkaloids.*

They are nitrogenized bodies, obtained from vegetables, and behaving towards the acids as does ammonia; it is to their resemblance to this alkali that they owe the name alkaloid = an alkali-like body.

919. *How do nicotine and conine differ from the other alkaloids?*

They are liquid and volatile, while the other alkaloids are solid; they are also the only alkaloids into whose composition oxygen does not enter.

920. *Whence is conine obtained, and what are its properties?*

From hemlock leaves, Conium, U. S. P. A colorless, oily liquid, lighter than water, having a disagreeable, penetrating odor; sparingly soluble in water, readily in alcohol and ether. It has a strong alkaline reaction and forms neutral, amorphous salts with most acids; it deteriorates rapidly on exposure to air, becomes colored, and finally resinous. It is a very active narcotic poison, producing death by asphyxia from paralysis of the voluntary muscles.

921. *Give the source and properties of nicotine.*

It is obtained from tobacco; the oily liquid which condenses in tobacco-pipes is very rich in nicotine. It is an oily, colorless, transparent liquid, heavier than water, having a burning taste and a faint odor of tobacco, which becomes more powerful upon the application of heat; it is quite volatile,

and its vapors are very irritating. Very soluble in water, alcohol and ether; when exposed to the air it absorbs moisture, becomes brown and is oxidized. It is very alkaline, and forms well-defined salts with acids. It is a very violent poison, and very rapid in its action.

OPIUM ALKALOIDS.

922. *Name the principal alkaloids existing in opium.*

Morphine, codeine, narceine, narcotine, thebaine, papaverine.

923. *In what form do these probably exist in opium?*

In combination with a peculiar organic acid known as meconic acid.

924. *State the properties of morphine.*

It crystallizes in colorless, transparent, odorless prisms, having a persistent bitter taste; soluble in 500 parts of boiling water, insoluble in ether and chloroform, soluble in 13 parts of boiling alcohol. Morphine and its salts are very prone to oxidation.

925. *What salts of morphine are officinal?*

The acetate, hydrochlorate, and sulphate.

926. *Give tests for the presence of morphine.*

With neutral solutions of morphine, or of its salts, a *neutral* solution of ferric chloride produces a blue color, which disappears upon the addition of an acid. Solid morphine, added to concentrated nitric acid, forms a reddish yellow solution.

927. *Give a test for the presence of meconic acid.*

With a *neutral* solution of ferric chloride a red color is produced, which is *not* discharged upon the

addition of mineral acids or of solution of mercuric chloride.

928. *How much morphine does opium contain?*

10 to 15 per cent.

929. *Which is the most actively poisonous of the opium alkaloids?*

Thebaine.

930. *How is apomorphia obtained?*

By heating hydrochlorate of morphine with excess of hydrochloric acid, in a sealed tube, to 300°, for two or three hours, and purifying the crude product thus obtained.

CINCHONA ALKALOIDS.

931. *Name the two most important alkaloids of cinchona bark.*

Quinine and cinchonine.

932. *With what peculiar acid are they combined in nature?*

Kinic acid.

933. *State the physical properties of quinine.*

A light, white, amorphous powder, without odor, having a tenacious, bitter taste and an alkaline reaction. Very sparingly soluble in water, readily soluble in alcohol, chloroform, and ether. It separates on evaporation of its alcoholic or ethereal solution in crystals containing 3Aq.

934. *Explain the solubility of quinine in dilute acids.*

The quinine combines with the acid to form a salt which is soluble.

935. *What salt of quinine is commonly used in medicine, and what are its physical properties?*

The sulphate. It crystallizes in thin, light, white needles, with 7Aq; sparingly soluble in water, readily in boiling alcohol and in ether. It dissolves readily in dilute sulphuric acid, the soluble bisulphate being formed. Solutions of this salt, although they are colorless by transmitted light, present beautiful pale blue reflections.

936. *By what reactions may quinine be recognized?*

1. By the blue reflections (fluorescence) of its solution in dilute sulphuric acid. 2. When chlorine water and aqua ammoniæ are added to quinine solution it assumes a green color. 3. A deep red color is produced in solutions of quinine when chlorine-water, potassium ferrocyanide and aqua ammoniæ are added in the order named.

937. *How is quinine frequently adulterated?*

With gypsum, stearic acid, starch, salicin and sulphate of cinchonine.

938. *How may the presence of mineral substances be detected?*

By heating to redness; if any mineral matter be present it remains after heating, while pure quinine is entirely volatilized.

939. *How is the presence of cinchonine detected?*

Place a gram of the sample in a test-tube; add 10–15 grams of ether and 2 grams of aqua ammoniæ, shake, and allow the mixture to separate into two layers; if cinchonine be present it will appear as a precipitate in the lower layer.

940. *How may the other adulterations named be detected?*

Stearic acid may be detected by its insolubility in dilute sulphuric acid; starch by its insolubility

in boiling alcohol; and salicin by the red color produced upon the addition of sulphuric acid.

STRYCHNOS ALKALOIDS.

941. *What two important alkaloids belong to this class?*

Strychnine and brucine.

942. *Give the properties of strychnine.*

It crystallizes in small, transparent, four-sided prisms; odorless, having an intensely bitter taste and an alkaline reaction; very sparingly soluble in water, soluble in benzine, chloroform and boiling dilute alcohol, insoluble in absolute alcohol, ether and solutions of the alkalies. It is a strong base, neutralizing acids and forming salts, most of which are crystalline, soluble in water and very bitter.

943. *How is strychnine held in solution in Liquor strychniæ, U. S. P.?*

In preparing the Liq., dilute hydrochloric acid is used, with which strychnine forms the soluble hydrochlorate.

944. *What other salt of strychnine is officinal?*

The sulphate.

945. *Give tests for strychnine.*

1. When pure it is not colored by nitric acid. 2. When strychnine, lead peroxide and concentrated sulphuric acid are triturated together, the mixture becomes blue, then violet, red and, after a time, canary yellow. 3. When chlorine is passed through a solution of strychnine a white precipitate is formed. 4. When strychnine in solution is injected into the lymph-pouch of a frog the animal is seized with violent tetanic spasms upon the slightest touch,

upon being breathed upon, or when the surface on which it rests is jarred.

946. *Give a test for brucine.*

Upon the addition of nitric acid a bright red color is produced, which gradually turns to yellow on the addition of stannous chloride, or to reddish violet on the addition of ammonium sulphydrate.

OTHER ALKALOIDS.

947. *Whence is atropine obtained?*

From belladonna root.

948. *What are its characters?*

It crystallizes in silky needles, having a faint yellowish tinge and persistent bitter taste; odorless; sparingly soluble in water, readily in alcohol.

949. *What salt of atropine is used in medicine?*

The sulphate.

950. *What alkaloid occurs in Calabar bean?*

Physostigmine or esserine.

951. *Give the names and sources of some other alkaloids.*

Aconitine, from aconite root; Beberine, from nectandra; Hyoscyamine, from henbane; Veratrine, from veratrum album; Colchicine, from colchicum.

952. *How should cases of poisoning by the alkaloids be treated?*

The chief indication is to remove any portion of the poison remaining in the stomach, as rapidly as possible; an emetic of sulphate of zinc should be given, or, if this be not feasible, a hypodermic injection of apomorphia. The stomach-pump should be used and the stomach washed out with infusion of tea, or with water holding powdered animal char-

coal in suspension; chemical antidotes are of little value. Where physiological antidotes exist they should of course be used.

ANIMAL COLORING-MATTERS.

953. *By what names is the coloring-matter of the blood known?*

Hæmoglobin, hæmatocrystallin and cruorin; the first is the name now in general use.

954. *In what portion of the blood does it exist?*

In the corpuscles.

955. *What are its physical properties?*

It is, when pure, a crystalline solid, more or less soluble in water, soluble in dilute alcohol and in dilute solutions of the alkalies; not capable of dialysis although crystalline. Red or purple in color.

956. *How does hæmoglobin from the blood of different kinds of animals differ in physical properties?*

In the facility with which it forms crystals and in the form of the crystals. In its solubility; the crystals from the blood of the ox are very readily soluble in water, while those from the blood of the raven are almost insoluble in that fluid.

957. *Of what elements is hæmoglobin composed?*

Carbon, hydrogen, nitrogen, oxygen, sulphur and iron.

958. *What is the object of administering iron in anæmia?*

To furnish one of the important constituents of the corpuscles, which are deficient in this condition.

959. *Explain the change which hæmoglobin undergoes in passing through the lungs.*

Hæmoglobin exists in the blood in two different conditions of oxidation, which are designated by the names oxyhæmoglobin and reduced hæmoglobin; the latter contains the less quantity of oxygen, and exists in venous blood; as the blood circulates in the lung it is separated from the air in the air cells by a very thin membrane through which the oxygen passes into the blood; it enters into a peculiar loose chemical combination with the coloring-matter to form oxyhæmoglobin.

960. *What change does oxyhæmoglobin undergo in the capillary circulation, and what is its function?*

The opposite change occurs to that which takes place in the pulmonary circulation; the oxyhæmoglobin is decomposed, oxygen passes into the tissues, and reduced hæmoglobin returns by the venous system to the lungs to receive a fresh supply of oxygen. The coloring-matter is, therefore, the carrier of oxygen from the air to the tissues.

961. *How may the two conditions of hæmoglobin be distinguished by the spectroscope?*

Solutions of oxyhæmoglobin present two absorption bands, between the solar lines D and E; that nearer D being narrower, sharper and darker than that nearer E; solutions of reduced hæmoglobin, on the other hand, show a single broad band occupying about the space left bright between the oxyhæmoglobin bands and more faint and ill-defined than either of those.

962. *What action has carbon monoxide on oxyhæmoglobin?*

It drives out all of the loosely combined oxygen, and forms, with the reduced hæmoglobin, a compound which is much more stable than oxyhæmo-

globin, and from which the carbon monoxide cannot be again displaced by oxygen.

963. *What is hæmatin?*

An uncrystallizable coloring-matter formed by the decomposition of hæmoglobin.

964. *Name the principal coloring-matters of the bile.*

Bilirubin and biliverdin.

965. *State the properties of bilirubin.*

It forms microscopic, orange or brick-red crystals, soluble in chloroform or benzine, insoluble in water, ether, alcohol and dilute acids, soluble in dilute alkalies. When acted upon by oxidizing agents it is converted into biliverdin.

966. *Describe Gmelin's reaction for bile pigments.*

Spread the fluid to be tested in a thin layer upon a white plate, and add a few drops of nitroso-nitric acid (nitric acid containing the lower oxides of nitrogen); if bile pigments be present a play of colors will be observed at the line of junction of the two fluids in the following order: blue, violet, red and dirty yellow.

967. *To what substances does urine probably owe its color?*

To at least two coloring-matters; indican and urobilin.

ALBUMINOUS SUBSTANCES.

968. *State the characters of these substances.*

They are nitrogenized bodies, not capable of crystallization, having, when dry, the appearance of gum arabic, odorless, insipid; insoluble in ether and alcohol, their solubility in water varies accord-

ing to the temperature and the presence or absence of alkalies, acids and mineral salts. They enter very readily into the series of changes designated by the term putrefaction. Their chemical composition is not constant, and they are probably mixtures of undetermined substances.

969. *What is understood by coagulation?*

The property of albuminous substances of being converted into insoluble modifications by the action of heat, mineral acids, alcohol and certain metallic salts. When once converted into this modified substance, the albuminoids will not return to their primitive form.

970. *Give reactions for the detection of albuminous substances.*

1. They are dissolved by boiling hydrochloric acid, the solution being violet-red in color. 2. They turn yellow when warmed with concentrated nitric acid. 3. Iodine produces a brown stain in the cold. 4. Solution of mercuric nitrate with excess of nitric acid (Millon's reagent) gives a fine, red color when warmed with an albuminous substance. 5. With Pettenkofer's reaction, the same result is obtained with albuminous matters as with the biliary salts. (See Q. 702.)

971. *State the characters of fibrin.*

White, elastic filaments interlaced in all directions, insoluble in water. When treated with dilute acids it swells and gradually dissolves, although usually incompletely.

972. *Does fibrin pre-exist in the blood?*

No: it is formed at the instant of separation.

973. *Explain its formation.*

There exist in the plasma two albuminous sub-

stances, known as paraglobulin and fibrinogen, the former being greatly in excess of the latter. Under proper conditions, these two substances unite with each other to form fibrin. When all the fibrinogen of the blood has been converted into fibrin, no further coagulation will take place, unless upon the addition of a further quantity of fibrinogen, which then unites with the remaining paraglobulin to form another quantity of fibrin.

974. *What is understood by "serum albumen"?*

That portion of the albuminous constituents of the blood plasma which is coagulated, after the separation of fibrin, upon the application of heat. It is a mixture of at least two, and probably of a greater number, of albuminous substances, one of which is the paraglobulin in excess of fibrinogen, mentioned in Q. 973.

975. *To what substance is the name* albumen *applied, and how may it be distinguished from "serum albumen"?*

To an albuminoid substance existing in the white of egg, coagulable by heat, upon the addition of nitric acid, and upon being shaken with ether; "blood albumen" is not affected by ether.

976. *What peculiar albuminous substance exists in milk, and what are its properties?*

Casein. An amorphous, white substance, tasteless and odorless, very soluble in alkaline fluids. Coagulates with acids, and under the influence of infusion of *rennet* (mucous membrane of fourth stomach of calf), but not by heat.

977. *Into what substance are all albuminous bodies converted by the action of the gastric juice?*

Into albuminose or peptone.

978. *By what constituents of the gastric juice is this change brought about?*

By the combined action of the free acid and an albuminous substance, known as pepsin, peculiar to the gastric juice. Neither pepsin nor an acid will produce the change alone.

979. *In what important point does albuminose differ from other albuminous substances?*

In being capable of dialysis, *i. e.*, passing through animal membranes, which other albuminous substances are incapable of. It is in the form of albuminose that the food elements of this class pass from the intestine into the blood.

980. *Whence is gelatin obtained, and how?*

From bones, tendons, fish bladders, skins, etc. These tissues contain a peculiar substance, called collagen, in combination with mineral and other matters. When collagen is heated with water, under such a pressure that the temperature reaches 106°, a solution is formed which, on cooling, solidifies to a jelly. This jelly yields a new substance, which is gelatin, glue, isinglass, or size, according to the substance used, and peculiarities in the manufacturing process followed.

URINE.

981. *What quantity of urine is normally excreted by an adult in 24 hours?*

About 1,200 cbc. It may vary in health from 900 to 1,500 cbc.

982. *Under what circumstances is the quantity normally above the average?*

When large quantities of fluids have been in-

gested, in beer-drinkers; in winter; in individuals of sedentary habit.

983. *Under what conditions is the quantity normally below the average?*

In summer and, generally, under all conditions which increase the amount of perspiration and pulmonary exhalation.

984. *In what pathological conditions is the quantity increased?*

In both forms of diabetes; after hysterical paroxysms; sometimes in hypertrophy of the left ventricle, and in other conditions increasing the blood pressure.

985. *In what pathological conditions is the quantity diminished?*

In acute febrile diseases; in all diseases attended with watery discharges or dropsical effusions. In retention or suppression of urine from any cause.

986. *What are the characters of the small quantities of urine forced through in obstructive suppression?*

It is of low specific gravity, and, unless tinged with blood, pale in color.

987. *How should urine be examined for color?*

It should be acidulated with hydrochloric acid, boiled, and allowed to stand for twelve hours, after which it should be placed in a beaker of about three inches diameter, and the color observed by transmitted light.

988. *Describe how the color may vary physiologically.*

The greater the quantity of urine the lighter the color, as a rule. The morning urine is darker than that voided at other times, and the use of

animal food also produces a high-colored urine. The use of certain drugs communicates a peculiar color to the urine: rhubarb, bright yellow; senna, brownish; logwood, reddish; santonin, orange-red or golden-yellow.

989. *Under what pathological conditions is the urine pale?*

Under those conditions which produce an increase in the quantity, and in anæmia; in the latter condition the quantity is not increased.

990. *Under what conditions is it high colored?*

Under those conditions in which the quantity of water eliminated by the kidneys is diminished while the elimination of solids remains normal, or is increased; such urines have a high specific gravity and are strongly acid. As the coloring matter of the urine is a product of the disassimilation of hæmoglobin, an absolute increase in the quantity of urine-pigment eliminated indicates an increased destruction of blood corpuscles.

NOTE.—A comparatively light-colored urine is frequently found, on being boiled with acid, to contain a large quantity of coloring-matter, which, before the action of the acid, was in the form of a colorless combination.

991. *To what do brown and black urines owe their color?*

To the presence of abnormal coloring matters, blood or bile. (See Q. 966, 1024.)

992. *What is the specific gravity of normal urine?*

From 1015 to 1025. This may vary within wide limits without the presence of any diseased condition; after copious drinking upon an empty stomach, urine of as low a specific gravity as 1001 may be voided, while the sp. gr. may rise to 1030 after a

full meal. The urine of females is generally of a little lower sp. gr. than that of males, except during pregnancy, when it has normally a sp. gr. of about 1030.

993. *Of what value is the sp. gr. of urine as a clinical indication?*

It indicates, in a rough way, the quantity of solids, heavier than water, in solution in the urine, the chief of these being urea. Taken in connection with the quantity of urine voided, the sp. gr. affords an approximate indication of the amount of disassimilation taking place in the economy.

994. *What are the physical properties of urine in diabetes?*

It is excessive in quantity, pale in color, and of high specific gravity.

995. *How is the sp. gr. of urine affected by the presence of albumen?*

It is lowered.

996. *What is the normal reaction of the urine?*

It is usually acid.

997. *How is the reaction influenced by the food?*

The urine of the herbivora is alkaline, and that of the carnivora is strongly acid; when the food of man is a mixture of animal and vegetable substances the reaction of the urine is acid; under a purely animal diet the acidity is markedly increased, while under a vegetable diet the reaction becomes alkaline. Whether the food be animal, vegetable, or mixed, the acidity of the urine diminishes after meals, and the reaction even becomes alkaline; the urine which is separated during the period of greatest activity of gastric digestion is alkaline.

998. *How may we determine whether the alkalinity*

of a urine is due to ammoniacal or to potassium or sodium compounds?

By drying and gently warming the blued litmus-paper, if the alkalinity be due to ammonium compounds the red color returns; if it be due to potassium or sodium compounds the blue color remains.

999. *Of what clinical interest is the determination of this point?*

An alkaline reaction of the urine, due to potassium or sodium compounds, does not indicate any pathological condition. If, on the other hand, a urine be alkaline, *when voided*, from the presence of ammoniacal compounds some inflammatory disorder of the bladder or urinary passages exists. The ammonium compounds are produced by the decomposition of urea and all urines become ammoniacal, sooner or later, after being discharged; but when the decomposition occurs in the bladder it is due to the influence of an increased quantity of mucus. Ammoniacal urine is usually sedimentary, and is favorable to the formation of calculi.

1000. *How is urea formed in the economy?*

By the oxidation of the nitrogenized constituents of the body.

1001. *What quantity of urea is discharged by a normal adult in 24 hours?*

From 25 to 35 grams.

1002. *How does the elimination of urea vary with age and sex?*

Taking the quantity excreted in 24 hours by an average adult man at 0.5 grm. for each kilogram of body weight, it is found that in young children the elimination is much greater; a child of 6 years discharges in 24 hours 1 grm. urea for each kilo.

of body weight. In old persons the elimination of urea diminishes. Females discharge less urea than males, except during pregnancy, when the elimination is much increased.

1003. *How does the diet affect the elimination of urea?*

The more highly nitrogenized the diet the greater the elimination of urea.

1004. *Give a clinical method for determining whether the elimination of urea is excessive or deficient.*

Take from the fresh, mixed urine of 24 hours two samples, one of 5 cbc. and the other of double that quantity and place them in watch glasses; to the smaller sample add about one-third of its volume of pure *colorless* nitric acid; if crystals appear in this immediately or within a few moments the amount of urea is above the normal. Evaporate the other sample to one-half its bulk at a low temperature (over a water-bath or on the corner of a stove where the temperature does not exceed 90°), allow it to cool and add nitric acid as before, if crystals do not form within a few moments the proportion of urea is below the normal.

The quantity of urine passed in 24 hours must be taken into consideration; thus, if instead of the normal quantity of 1,200 cbc., the patient only pass 600 cbc., the first sample should be diluted with its own volume of water, and the second used without evaporation; if, on the other hand, the urine be that of a diabetic patient, passing 3,600 cbc. per diem, 15 cbc. of the urine reduced to 5 by evaporation should be used for the first test, and 30 cbc. reduced to 5 for the second.

NOTE.—I have given none of the more elaborate and so-called accurate quantitative processes for urea, as they are all more or less subject to error, require corrections and care, and expenditure of time in the performance. All the processes hitherto devised are subject to an error from the presence in the urine of kreatinin, and other substances, which are decomposed by the reagents used; one of the products of the decomposition is urea, and this, being in turn decomposed, vitiates the result. Two processes have been very generally used by practitioners: Liebig's and Davy's. The former requires the use of a titrated solution whose preparation is difficult and uncertain, and which deteriorates rapidly; it is also open to the objection that the result obtained requires corrections, as it is modified by the degree of concentration of the urine and by the presence of sodium chloride or albumen. Davy's process is only approximative and requires corrections for variations in barometric pressure and temperature. The most nearly accurate process which I am acquainted with is that devised by Dr. J. C. Draper, in which the urea is decomposed and the carbon dioxide formed is weighed as barium carbonate.

1005. *To what pathological causes may diminution or increase of elimination of urea be due?*

A diminution may be due to some condition interfering with the normal transformation of albuminous substances in the body, as in certain chronic diseases; more frequently, however, a diminished proportion of urea in the urine is not due to a diminution in the production, but to the fact that the urea formed has not been separated by the kidneys, as in uræmia, and in diseases attended with dropsical effusions. An excess of urea occurs in fevers and in true diabetes, in which it indicates the amount of waste of tissue, and is, therefore, a grave symptom.

1006. *How much uric acid is normally excreted in 24 hours?*

From 0.3 to 0.8 gram.

1007. *Give a process for the quantitative determination of uric acid in urine.*

Place 200 cbc. of urine in a beaker, add 5 cbc. pure hydrochloric acid; stir, cover, and set aside for 24 hours; collect the crystals formed upon a small weighed filter, wash with cold distilled water until the washings no longer precipitate with silver nitrate; dry the filter with the adhering crystals and weigh, the difference between this weight and that of the filter gives the amount of uric acid. A slight correction is required for the sparing solubility of uric acid. If the amount of wash water used do not exceed 30 cbc. no correction is required; if it do, add to the result 0.045 milligr. for each cbc. more than 30 used.

1008. *What salts of mineral acids exist in the urine?*

Chlorides and sulphates of potassium and sodium; phosphates of potassium, sodium, magnesium, and calcium.

1009. *Explain how a portion of the sulphates and phosphates is formed in the economy.*

Albuminous substances contain sulphur as a part of their constituent elements; during the processes of nutrition the albuminoids are decomposed, and their sulphur is finally oxidized into sulphuric acid; this immediately unites with sodium or potassium, which it takes from some weaker acid. In the same way the phosphates are formed by the oxidation of the phosphorus entering into the composition of certain constituents of nerve-tissue.

1010. *What phosphates in the urine may form calculi, and why?*

Those of calcium and magnesium, sometimes

known as "earthy phosphates." These salts are comparatively soluble in acid fluids, but almost insoluble in neutral or alkaline fluids; when, therefore, the urine has a tendency to alkalinity it also has a tendency to deposit phosphatic gravel or calculi.

1011. *Explain the formation of ammonio-magnesian phosphate.*

The magnesium phosphate of the urine is the mono-salt, PO_4HMg, which still has an atom of the acid hydrogen; whenever an ammonium compound, formed in the urine by decomposition of urea, is in presence of this salt the ammonium displaces the remaining hydrogen, and the nearly insoluble "triple phosphate" is formed:

$$\underset{\text{Monomagnesic phosphate.}}{PO_4HMg} + \underset{\text{Ammonium hydrate.}}{(NH_4)HO} = \underset{\text{Ammonio-magnesian phosphate.}}{PO_4(NH_4)Mg} + \underset{\text{Water.}}{H_2O}$$

1012. *Is sugar a normal or abnormal constituent of human urine?*

It exists normally in quantities too small to be distinguished by the ordinary tests; its presence is pathological only when the quantity is so increased that it may be detected by the methods generally used, the gravity of the disorder being proportionate to the quantity of sugar eliminated.

1013. *Describe Trommer's test.*

To the urine, in a test-tube, add one or two drops of a solution of cupric sulphate, and then about half as much liq. potassæ as there was urine, shake and boil; if sugar be present a yellow or red precipitate of cuprous oxide is formed. The presence of albumen interferes with this reaction; if, there-

fore, the urine be albuminous it should be heated to the boiling point and filtered before the application of the test. In applying Trommer's or Fehling's test to urine, a dirty yellowish-green color is frequently observed; this is *not* due to the presence of sugar.

[Fehling's test is based upon the same reaction as Trommer's, and is more delicate. Two solutions are required:

I.	Cupric sulphate (pure),	51.98 grams.
	Water,	500 cbc.
II.	Rochelle salt (pure crystals),	259.9 grams.
	Solution sodic hydrate, sp. gr. 1.12,	1,000 cbc.

(Piffard.)

In using, mix one volume I. with two volumes II. in a test tube, shake, add an equal volume of the urine to be tested, and boil; if sugar be present the same appearance is observed as in Trommer's test. This solution may be used in determining the quantity of sugar in urine: place 20 cbc. of the mixed solutions diluted with 60 cbc. water in a flask and boil; dilute the urine to be tested with four volumes of water; fill a burette with the diluted urine, and from this gradually add it to the boiling liquid until the blue color has been entirely discharged; at this point read on the graduation of the burette the number of cbc. used, divide this number by five, and the quotient gives the number of cbc. urine containing 0.1 gram. sugar; from this the quantity in any given volume of urine is obtained by simple proportion.]

1014. *Explain the principles upon which Trommer's and Fehling's tests are based.*

By the action of the boiling alkali glucose is converted into substances (glucic and melassic acids) which are very prone to oxidation and are consequently good reducing agents; if cupric sulphate be present it is converted into cuprous sulphate, and this is in turn decomposed with deposition of cuprous oxide. As there is deoxidation of the copper compound these tests are spoken of as "reduction tests."

1015. *How is the fermentation test conducted?*

Take three test-tubes, A, B, and C, place in each some washed yeast, fill A completely with the urine to be tested, and place it in an inverted position, the mouth below the surface of some of the same urine in a flat vessel (the entrance of air being prevented, during the inversion, by closing the opening of the tube with the finger until it has been brought below the surface of urine). Fill B completely with some urine to which glucose has been added, and C with distilled water, and invert them in the same way as A; B in saccharine urine, and C in distilled water. Leave all three tubes in a place where the temperature is about 25°, for twelve hours, and then examine them. If gas have collected in B over the surface of the liquid, and none in A, the urine is free from sugar; if gas have collected in both A and B, and not in C, the urine contains sugar; if no gas have collected in B, the yeast is worthless, and if any gas be found in C the yeast itself contains CO_2; in the last two cases the process must be repeated with a new sample of yeast.

1016. *Describe Robert's method for determining the quantity of sugar in urine.*

The specific gravity of the urine is carefully observed at 25°, yeast is then added and the urine maintained at 25° until fermentation has stopped; the sp. gr. is again observed; it will now be found lower than before; each degree of diminution of sp. gr. represents 0.2196 grms. of sugar in each 100 cbc. of urine.

1017. *What precaution is to be observed before testing for sugar?*

The urine should first be tested for albumen, if this be present it should be removed by heating the urine to near the boiling point, and filtering from the coagulum.

1018. *How is urine tested for albumen?*

By the action of heat and of nitric acid; both tests must be used, as neither is of itself conclusive.

1019. *Describe the heat test.*

The reaction is first observed; if it be acid the urine is simply heated to near the boiling-point; if the urine be neutral or alkaline it is rendered *faintly* acid by the addition of acetic acid and heated; if albumen be present a coagulum is formed, varying in quantity from a faint cloudiness to entire solidification according to the quantity of albumen present; the coagulum is not redissolved upon the addition of nitric acid.

1020. *What are the sources of error to be avoided?*

Albumen is slightly soluble in alkaline liquids, the urine is therefore rendered acid to prevent small quantities of albumen remaining in solution upon the application of heat, and thus escaping detection; albumen is also slightly soluble in dilute nitric acid, therefore acetic acid is used. The phosphates, in faintly acid urine, are held in solution principally by the presence of carbon dioxide; when the urine is heated this is driven off and the phosphates may be precipitated in a form closely resembling albumen; to remove this source of error nitric acid is added after heating; it dissolves the phosphates but does not affect the albumen. Nitric acid cannot be used alone as a test for albumen, because if the urine contain an excess of urates, these are decomposed upon the addition of acid,

and the almost insoluble uric acid is precipitated and might easily be mistaken for albumen.

1021. *How may minute traces of albumen be detected?*

Place in a test-tube a layer of nitric acid about 2 centim. in thickness, then, with a glass tube, carefully float upon the surface of this a layer of the urine in such a manner that the liquids do not mix; if albumen be present a cloudy ring appears *at* the point of junction of the two layers, the borders of the cloud being sharply defined. A cloudy ring may be formed by the presence of an excess of urates, but in this case it is not at, but above the point of junction of the layers, and its upper border is not sharply defined, but is ragged and fades off gradually.

1022. *Give a process for determining the quantity of albumen in urine.*

Heat a known volume of acid urine to near the boiling point, collect the coagula upon a weighed filter, wash with water, dry the filter with adhering albumen at 100°, weigh. The difference between the two weighings indicates the quantity of dry albumen in the volume of urine used. [Some authors direct to weigh the filter and albumen wet, when this is done there is no approach to accuracy as it is impossible to judge how much water is being weighed.]

1023. *Why should albuminous urine always be examined microscopically?*

To determine the presence or absence of blood or pus corpuscles, spermatozoa and casts. When the urine contains blood, pus or spermatic fluid it is always slightly albuminous, the presence of albu-

men has then no clinical importance beyond that attaching to the fluids named. Casts are never present in the urine of persons free from organic disease of the kidneys.

1024. *How may the presence of blood-coloring matter be detected in urine?*

Add acetic acid, boil, separate the brownish coagula and boil them with alcohol containing sulphuric acid, examine the alcoholic solution spectroscopically. The absorption bands of hæmoglobin are frequently visible in the urine without any previous treatment. (See Q. 961.)

APPENDIX.

A.

ELEMENTS.

Aluminium	Al	27.5
Antimony	Sb	122
Arsenic	As	75
Barium	Ba	137
Bismuth	Bi	210
Boron	B	11
Bromine	Br	80
Cadmium	Cd	112
Cæsium	Cs	133
Calcium	Ca	40
Carbon	C	12
Cerium	Ce	92
Chlorine	Cl	35.5
Chromium	Cr	52.5
Cobalt	Co	59
Copper	Cu	63.5
Didymium	D	96
Erbium	E	112.5
Fluorine	F	19
Gallium	Ga	
Glucinum	Gl	9.5
Gold	Au	197
Hydrogen	H	1
Indium	In	75.5 (?)
Iodine	I	127
Iridium	Ir	198
Iron	Fe	56
Lanthanium	La	92
Lead	Pb	207

Lithium	Li	7
Magnesium	Mg	24
Manganese	Mn	55
Mercury	Hg	200
Molybdenum	Mo	96
Nickel	Ni	59
Niobium	No.	94
Nitrogen	N	14
Osmium	Os	199
Oxygen	O	16
Palladium	Pd	106.5
Phosphorus	P	31
Platinum	Pt	197.5
Potassium	K	39
Rhodium	Rh	104
Rubidium	Rb	85.5
Ruthenium	Ru	104
Selenium	Se	79.5
Silicium	Si	28
Silver	Ag	108
Sodium	Na	23
Strontium	Sr	87.5
Sulphur	S	32
Tantalum	Ta	182
Tellurium	Te	128
Thallium	Tl	204
Thorium	Th	234
Tin	Sn	118
Titanium	Ti	50
Tungsten	W	184
Uranium	U	120
Vanadium	V	51.5
Yttrium	Y	61.5
Zinc	Zn	65
Zirconium	Zr	89.5

B.

METHOD FOR DETERMINING THE COMPOSITION OF AN INORGANIC COMPOUND.

Three cases may arise, either:

I. The substance is entirely soluble in water, or is already in aqueous solution.

II. It is insoluble in water, but soluble in acids, either dilute or concentrated.

III. It is insoluble in water and in acids.

I. *The substance is in aqueous solution. Determination of the base.*

1. Acidulate with HCl:
   - *a.* No precipitate is formed. 3
   - *b.* A white precipitate is formed. 2
2. Collect ppt. on filter, add $(NH_4)HO$:
   - *a.* It dissolves. ..... *Silver.*
   - *b.* It turns black. ..... *Mercury(ous).*
   - *c.* It is unaltered. ..... *Lead.*
3. Pass SH_2 through the clear, acid solution:
   - *a.* No ppt. is formed. 11
   - *b.* A ppt. is formed. 4
4. Collect ppt. on filter, wash with water containing SH_2; treat with $(NH_4)HS$:
   - *a.* The ppt. is dissolved. 5
   - *b.* It is insoluble. 8
5. Add HCl to solution 4 *a* to acid reaction; the ppt. is:
   - *a.* Black. 6
   - *b.* Brown. ..... *Tin(ous).*
   - *c.* Yellow. 7
   - *d.* Orange, and soluble in HCl. ..... *Antimony.*
6. The original solution:
   - *a.* Gives brown ppt. with sol. SO_4Fe. ..... *Gold.*
   - *b.* Does not give brown ppt. with SO_4Fe, but gives yellow ppt. with KCl. ..... *Platinum.*
7. Precipitate obtained in 5 *c* is:
   - *a.* Soluble in HCl, and not volatilized by heat. ..... *Tin(ic).*
   - *b.* Nearly insoluble in HCl; soluble in $(NH_4)HO$, and entirely volatilized by heat. ..... *Arsenic.*
8. The ppt. obtained in 4 *b* is:
   - *a.* Black or brown. 9
   - *b.* Yellow ..... *Cadmium.*

9. The ppt. obtained in 8 *a* is:
   a. Insoluble in strong boiling NO_3H.... ...*Mercury(ic).*
   b. Soluble in boiling NO_3H..... 10
10. Add $(NH_4)HO$ to solution obtained in 9 *a*.
   a. A white ppt. is formed .....*Bismuth.*
   b. The solution turns blue .....*Copper.*
11. Neutralize the solution 3 *a* with $(NH_4)HO$, and add $(NH_4)HS$:
   a. A ppt. is formed 12
   b. No ppt. is formed 18
12. The ppt. is:
   a. Black 13
   b. Not black..... 15
13. Treat the ppt. with dilute HCl:
   a. It dissolves, and the solution yields a dark blue ppt. with potassium ferrocyanide . .....*Iron.*
   b. It is insoluble..... 14
14. Heat a fragment of the ppt. with borax on platinum wire in the blowpipe flame:
   a. A transparent blue bead is obtained.....*Cobalt.*
   b. A bead is obtained which is yellow when hot, and nearly colorless when cold.....*Nickel.*
15. Heat a fragment of the original substance with borax, as in 14, the bead is:
   a. Colored..... 16
   b. Colorless..... 17
16. *a.* The head is violet; the ppt. with $(NH_4)HS$ was flesh colored.....*Manganese.*
   b. The head is emerald green; the ppt. with $(NH_4)HS$ was bluish..... ..*Chromium.*
17. Add sol. CO_3Na_2 to the original solution, collect ppt., dry, heat before blowpipe on charcoal, add solution of $(NO_3)_2Co$, and heat again. To another portion of the original solution add excess solution KHO, and then solution of chromic hydrate in KHO:
   a. Treatment before blowpipe yields a blue mass. Cr solution forms no ppt.....*Aluminium.*
   b. Treatment before blowpipe yields a green mass. Cr solution forms green ppt.....*Zinc.*
18. Boil solution 11 *b* to expel SH_2; add (if necessary) $(NH_4)HO$ to alkaline reaction; then sol. $(NH_4)Cl$, and then sol. $CO_3(NH_4)_2$:
   a. A ppt. is formed 19
   b. No ppt. is formed..... 21

19. Add to the original solution sol. SO_4Ca:
    a. No ppt. is formed ..... *Calcium.*
    b. A ppt. is formed 20
20. Add hydrofluosilicic acid to portion of original solution:
    a. A ppt. is formed; a portion of the original solid colors the Bunsen flame green ..... *Barium.*
    b. No ppt. is formed; a portion of the original solid colors the Bunsen flame red ..... *Strontium.*
21. To solution 18 *b* add sol. PO_4HNa_2, and rub inner surface of vessel with glass rod:
    a. A white, crystalline ppt. is formed ..... *Magnesium.*
    b. No ppt. is formed 22
22. *a.* The original solution forms a yellow ppt. with $PtCl_4$, and does not give off NH_3 when heated with lime ..... *Potassium.*
    b. The original solution forms a yellow ppt. with $PtCl_4$, and gives off NH_3 when heated with lime ..... *Ammonium.*
    c. The original solution does not form ppt. with $PtCl_4$, and leaves a solid residue when evaporated; this residue colors the Bunsen flame yellow ..... *Sodium.*

Determination of the acid.

The compound does not carbonize when heated to redness.

1. On the addition of HCl in searching for bases:
    a. There was effervescence 2
    b. A gelatinous ppt. formed ..... *Silicate.*
    c. There was neither effervescence nor ppt 3
2. The gas given off:
    a. Was odorless, and formed a white ppt. when passed through lime-water ..... *Carbonate.*
    b. Had an odor of rotten eggs, and blackened paper moistened with sol. lead acetate ..... *Sulphide.*
3. In testing for bases:
    a. Arsenic was found 4
    b. Arsenic was not found 5
4. Add to the original solution sol. NO_3Ag containing $(NH_4)HO$, the ppt is:
    a. Yellow ..... *Arsenite.*
    b. Brick-red ..... *Arseniate.*

5. Add to the original solution $(NH_4)HO$ and $BaCl_2$:
   a. A ppt. is formed 6
   b. No ppt. is formed 8
6. Treat a part of the ppt. with HCl:
   a. It dissolves 7
   b. It is insoluble ..... *Sulphate.*
7. Treat another portion of the ppt. with acetic acid:
   a. It dissolves ..... *Phosphate.*
   b. It is insoluble ..... *Oxalate.*
8. Acidulate original solution with NO_3H, add sol. NO_3Ag:
   a. A ppt. is formed 9
   b. No ppt. is formed 11
9. Treat ppt. with $(NH_4)HO$:
   a. It dissolves 10
   b. It is insoluble. To the original solution add a drop of chlorine water and starch paste, a blue color is produced ..... *Iodide.*
10. The original liquid:
   a. Forms a blue ppt. with sol. SO_4Fe containing $(SO_4)_3Fe_2$ ..... *Cyanide.*
   b. Does not form ppt. as in *a*. Is not colored upon addition of chlorine water ..... *Chloride.*
   c. Does not form ppt. as in *a*. Is colored yellow or brown on addition of chlorine water ..... *Bromide.*
11. To a portion of the solid substance add SO_4H_2 and alcohol, warm, ignite, and stir:
   a. The flame is green. The solution, treated with a few drops HCl, turns turmeric paper brown. *Borate.*
   b. The appearances in *a* are not observed 12
12. If the base was an alkali, heat the salt to redness, dissolve the residue in water, and add sol. NO_3Ag. If the base was not an alkali, add to the sol. of the salt CO_3K_2, filter, evaporate filtrate to dryness, heat residue to redness, dissolve in water, add excess NO_3H, then sol. NO_3Ag:
   a. A flocculent ppt. is formed ..... *Chlorate.*
   b. No ppt. is formed. Heat the dry salt with copper and sulphuric acid, and conduct the gas evolved into a solution of $(SO_4)_3Fe_2$, which it turns brown ..... *Nitrate.*

If negative results are obtained in the above method, the base is combined with a volatile organic acid, or is an oxide or hydrate.

II. *The compound is insoluble in water, but is soluble in HCl, NO_3H, or aqua regia.*

The method is the same with the acid solution (diluted) as in I. up to 11. Before proceeding to 12, it must be determined whether the substance be not a phosphate or oxalate of calcium, barium or strontium, or a fluoride, thus:

1. Treat a portion of the ppt. obtained in I. 11 with SO_4H_2 in a platinum crucible, covered with a glass plate, a portion of whose lower surface is covered with wax; warm the crucible slightly (not enough to melt the wax):
   a. The uncoated surface of glass is corroded ... *Fluoride.*
   b. It is not affected 2

[If the substance be a fluoride, add to the residue in the crucible excess of sol. CO_3K_2, boil a few moments, filter, wash the residue thoroughly, add dilute HCl, collect this filtrate, and proceed from I. 18 to discover the base.]

2. Add a little tartaric acid and excess $(NH_4)HO$ to original acid solution:
   a. A ppt. is formed 4
   b. No ppt. is formed 3
3. To original acid sol. add excess sol. KHO until it is clear; divide into three parts. To one add excess sol. $(NH_4)Cl$, to another recently prepared sol. chromic hydrate in sol. KHO:
   a. Ppt. with $(NH_4)Cl$; none with Cr sol.... *Aluminium.*
   b. No ppt. with $(NH_4)Cl$; green ppt. with Cr sol... *Zinc.*
   To third portion add sol. SO_4Mg, and agitate; if a white, crystalline ppt. be formed, the Zn or Al was a..... *Phosphate.*
4. Add to original acid sol. excess sodic acetate and sol. $CaCl_2$; then acetic acid:
   a. A ppt. is formed which persists after addition of acetic acid... ..... *Oxalate.*
   b. No ppt. is formed, or it disappears on addition of acetic acid..... *Phosphate.*

[If the substance be an oxalate, heat a portion of the original solid to redness, dissolve the cooled residue in dil. HCl, and proceed with I. 18; if it be a phosphate, add excess sol. Fe_2Cl_6 to original acid sol., then $(NH_4)HO$, filter, and with filtrate proceed with I. 18.]

To detect acids not already found, proceed as follows:

1. Boil concentrated NO_3H with a portion of the solid:
   a. No colored vapors are given off; dilute NO_3H sol., filter, add sol. NO_3Ag; a white ppt.....*Chloride.*
   b. Violet vapors are given off, which give a blue color with water containing starch paste.....*Iodide.*
   c. Brown vapors are given off; dilute NO_3H sol. with much H_2O, add sol. $BaCl_2$; a white ppt...*Sulphide.*
   d. No reaction as in *a*, *b*, and *c*..... 2
2. Dissolve solid in HCl, dilute, filter, add sol. $BaCl_2$:
   a. White ppt.....*Sulphate.*

[If the base have been found by I. 1 to 11, and the acid have not been found as above, oxalic and phosphoric acids are yet to be searched for; this is done with the fluid from which the base has been separated according to I. 6, *acids.*]

III. *The substance is a salt insoluble in water and in acids.*

1. Moisten the solid with $(NH_4)HS$:
   a. It turns black..... 2
   b. It remains white..... 3
2. Digest the solid at a gentle heat with $(NH_4)HS$, separate the solution from the residue.
   Residue. Wash, dissolve in NO_3H, dilute with H_2O, and divide into two parts, to
      1. Add SO_4H_2; a white ppt.....*Lead.*
      2. Add HCl; a white ppt.....*Silver.*
   Solution. Divide into two parts:
      1. Add excess HCl, boil, dilute with H_2O, add $BaCl_2$.....*Sulphate.*
      2. Add NO_3H, boil, and search for chlorides, bromides, and iodides, according to I. 10, *acids.*
3. Mix solid in fine powder with four times its weight of CO_3NaK, and fuse; cool; add H_2O, boil:
   a. It dissolves entirely; add excess HCl to sol., evaporate to dryness, there remains a residue, insoluble in dil. HCl.....*Silicic acid.*
   b. A white residue remains. pour off H_2O, and set aside; wash residue, dissolve in dil. HCl, and test for Ba, Ca, and Sr, according to I. 18.

The water which has been set aside is to be tested for SO_4H_2 and F, for the first by $BaCl_2$ in acid solution, and the second by the action of FH on glass, II. 1.

C.

DESTRUCTION OF ORGANIC MATTER.

The following is the best method of removing animal matter previous to searching for mineral poisons:

If solid, the substance is cut into small pieces and suspended in water; if liquid, enough water is added to make a thin fluid. To this add about 200 cbc. HCl and 4 to 5 grams ClO_3K; heat the mixture over the water-bath, and, from time to time, add small portions of ClO_3K, until the mass has a uniform light yellow color; pass CO_2 through it until the odor of Cl disappears: filter; neutralize solution partially with CO_3Na_2; through the still acid liquid pass SH_2 for twelve hours, warm, and pass SH_2 through again; collect precipitate on filter, and wash with H_2O, containing H_2S, until free from chlorides (before testing for Cl, drive off SH_2 by heat, and add NO_3H). Dissolve precipitate in NH_4HS; if any insoluble portion remain, it is to be tested for Cu, Hg, and Bi. Evaporate solution to dryness at 100°, add NO_3H to residue, and heat over water-bath until NO_3H is driven off; mix residue with NO_3Na, and fuse, taking care that the mixture does not ignite; allow to cool, add SO_4H_2 in sufficient quantity to decompose nitrates; heat, and fuse until dense white fumes come off in abundance; allow to cool, dissolve in water, and test solution for Sb and As.

D.

EXAMINATION OF URINARY CALCULI.

1. Heat a portion to redness on platinum foil:
   - *a.* It is entirely volatile 2
   - *b.* A residue remains 5
2. Moisten a portion with NO_3H, evaporate nearly to dryness, add $(NH_4)HO$:
   - *a.* A red color is produced 3
   - *b.* No red color 4
3. Treat a portion with KHO, without heating:
   - *a.* An ammoniacal odor is observed ... *Ammonium urate.*
   - *b.* No ammoniacal odor ..... *Uric acid.*
4. *a.* The NO_3H solution becomes yellow on evaporation, the yellow residue becomes reddish-yellow on the addition of KHO, and, on heating with KHO, violet red ..... *Xanthin.*
   - *b.* The NO_3H solution becomes dark brown on evaporation ..... *Cystin.*
5. Treat as in 2:
   - *a.* A red color is produced 6
   - *b.* No red color 9
6. Heat before the blowpipe on platinum foil:
   - *a.* Fuses 7
   - *b.* Does not fuse 8
7. *a.* Colors the flame yellow ..... *Sodium urate.*
   - *b.* Colors the flame violet ..... *Potassium urate.*
8. The residue from 6:
   - *a.* Dissolves in dil. HCl with effervescence; the solution forms a white ppt. with ammonium oxalate ..... *Calcium urate.*
   - *b.* Dissolves with slight effervescence in dil. SO_4H_2; the solution, neutralized with $(NH_4)HO$, gives a white ppt. with PO_4HNa_2 ..... *Magnesium urate.*
9. Treat as in 6:
   - *a.* It fuses ..... *Ammonio-magnesian phosphate.*
   - *b.* It does not fuse 10
10. The residue from 6, when moistened with water, is:
    - *a.* Alkaline 11
    - *b.* Not alkaline ..... *Tricalcic phosphate.*
11. The original substance dissolves in HCl:
    - *a.* With effervescence ..... *Calcium carbonate.*
    - *b.* Without effervescence ..... *Calcium oxalate.*

E.

TABLES.

I.

Measures of length.

1 Kilometre = 1000 metres.	1 Millimetre = 0.001 metre.
1 Hectometre = 100 "	1 Centimetre = 0.01 "
1 Decametre = 10 "	1 Decimetre = 0.1 "

1 METRE = Unity.

1 Kilometre = 0.6214 mile.	1 Centimetre = 0.3937 inch.
1 Metre = 3.2809 feet.	1 Millimetre = 0.0394 "

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1 Foot = 30.48 centimetres. | 1 Inch = 2.54 centimetres.

Weights.

1 Kilogram = 1000 grams.	1 Milligram = 0.001 gram.
1 Hectogram = 100 "	1 Centigram = 0.01 "
1 Decagram = 10 "	1 Decigram = 0.1 "

1 *Gram.*

1 Kilogram = 2.679 lbs. Troy. | 1 Gram = 15.434 grains.

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1 Grain = 0.065 gram.	1 Dram = 3.887 grams.
1 Scruple = 1.295 "	1 Ounce = 31.099 "

1 Pound = 373.19 grams.

Measures of volume.

1 Cubic metre = 1000 litres. | 1 Cubic centimetre = 0.001 litre.

1 Litre = 1 cubic decimetre.

1 Litre = 2.11 pints. | 1 cbc. = 0.061 cubic inch.

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1 Minim = 0.0614 cbc.	1 Fluid ounce = 29 513 cbc.
1 Fluid dram = 3.689 "	1 Pint = 472 208 "

To convert thermometric scales.

Centigrade into Fahrenheit:

$$\frac{\text{Cent.} \times 9}{5} + 32 = \text{Fah.}$$

Fahrenheit into Centigrade:

$$\frac{\text{Fah.} - 32}{9} \times 5 = \text{Cent.}$$

INDEX.

B

Date Due
